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THE

AMERICAN NATURALIST

VOL. XXXI. December, 1897. 138

TRITUBERCULY: A REVIEW DEDICATED TO THE LATE PROFESSOR COPE.

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The morphology of the crowns of the mammalian teeth has sprung up practically as a new branch of study since Edward D. Cope and other paleontologists have demonstrated the unity of derivation of all the complex forms from the tritubercular type. The older works and ideas of Cuvier, Owen, Huxley and others are of comparatively little service now, for they treat the teeth of each order of mammals as of so many distinct types, whereas they must now be treated as modifications of one type. This new odontography of the mammalia may be dated from the time when it was recognized that the crowns of the teeth of the Unguiculata and Ungulata, in the comprehensive Linnæan sense, are based upon a common type and are composed of homologous elements of similar origin, as developed by Cope, Osborn, Scott, Schlosser and others. It dates also from the new embryology of the teeth as studied by Leche, Kükenthal, Taeker, Röse, Woodward and others, with the revelations as to primitive form, number, and milk succession.

But to fully establish the morphological branch in its new era we must first demonstrate the theory of a tritubercular

archetype. This has been opposed in one form or other by nearly all English morphologists, namely: Lankester, Forsyth-Major, Newton Parker, M. A. Woodward, E. S. Goodrich, Marion Tims. It has been accepted only by Flower and Lydekker. In Germany it has been accepted by v. Zittel, Schlosser and Rütimeyer; Schlosser, especially, has made important contributions to the evidence. The theory is accepted somewhat reservedly by the embryologists Röse, Leche, Taeker and others, who have attacked rather the homologies of the upper and lower cusps than the theory itself. In France it appears to have made little headway. In America, Scott, Allen, Wortman, Earle and many others are working upon the tritubercular theory and have made important additions to it. It is difficult for the writer to take the "primitive polybuny" hypothesis seriously, although it is advocated more or less positively by such able morphologists as Forsyth-Major, Lankester, Goodrich and Parker. The fact that the Multituberculates and Monotremes and certain Rodents exhibiting this type are primitive is no evidence that the polybunic type itself is primitive. We know nothing of the history of the degenerate Monotreme teeth, but we know that the further we go back among the ancestors of the Multituberculates and Rodents the less "polybunic" and more tritubercular they appear.

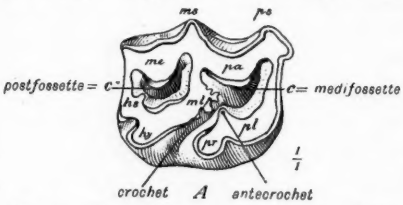


Fig. 1.—Horse Molar, *Merychippus*, Showing secondary folds.

This demonstration once made, as a matter of convenience in thought and description, we must revise the old systems of nomenclature which were based upon secondary forms rather than upon primary homologies, and which, as a rule, differ in every type of mammals and among odontologists of every land and establish a new odontography or descriptive method. Finally, we must trace out all the lines of divergence in both forms and determine the principles which guide them. The importance of a uniform nomenclature is seen at once in the

accompanying table of terms used among the rhinoceroses and horses alone. It could not have been anticipated that the diverse molars of the horse and of the rhinoceros, for example, would be limited in their variations, in a late geological period, by their unity of origin in an extremely early geological period. Yet such is undoubtedly the case. Compare the accompanying figures of *Merychippus* and of *Aceratherium*. Imagine that you see the simple bunodont molar of such a form as Owen's *Hyracotherium vulpiceps*, underlying these diverse crests and crescents. Consult Taeker's "Zur Kenntniss der Odontogenese bei Ungulaten" and you will find that this sexitubercular archetype is not imaginary, but is a constantly recurring fact of embryonic development—all the crests and crescents being preceded in the embryo by simple cones. Then compare carefully the variations in the two teeth as follows: The two "cement lakes" of *Merychippus* with the two "fossettes" of *Aceratherium*, enclosed in the former by crescentic spurs, and in the latter by the "antecrochet" and "crochet;"

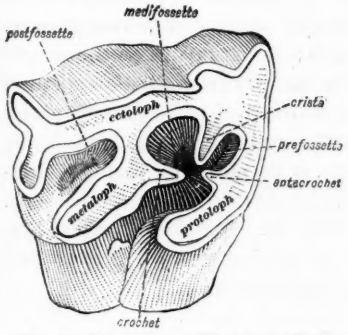


Fig. 2.—RHINOCEROS MOLAR. Undetermined species, showing secondary folds.

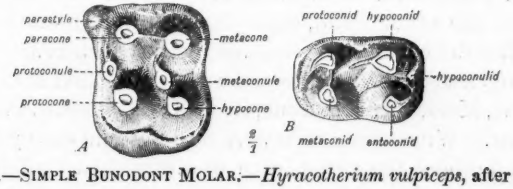


Fig. 3.—SIMPLE BUNODONT MOLAR.—*Hyracotherium vulpiceps*, after Owen.

the posterior "lake" and "fossette" similarly enclosed by an upgrowth of the posterior basal cingulum. Can any one question the homologies between these secondary adaptations to a diet of grasses when it is seen that they spring from the

same primary cusp centres? In the lower Eocene the sexitubercular prototype passes directly back into the tritubercular archetype. So throughout the whole mammalian scale not only ungulates, but primates, carnivores, insectivores, rodents are found playing similar variations upon the primitive tritubercular type. There are surprisingly few distinct types, but an almost unlimited number of sub-types, or variations of form. As we descend among the older rocks and the various series begin to converge, it becomes increasingly difficult to distinguish the different orders by their teeth alone. Thus it came about that all the Eocene monkeys were at first referred to the ungulates, or to transition groups, as expressed in M. Filhol's composite term *Pachy-lémuriens.*

TRITUBERCULAR HOMOLOGIES.

Embryological Evidence.—The progress which has been made in the embryology of the teeth is largely in the matter of the succession of double series, as indicated by vestiges of earlier and later sets of teeth, the so-called milk and permanent sets. Embryogenesis, however, has also led to a very minute study of the order of succession of the cones in the molar teeth, and without entering into the matter in detail, it may be briefly stated that all authors are unanimous in describing the cones of the lower molar teeth in different groups as developing in the same order in which they are supposed to have arisen in the past, according to the tritubercular theory, namely: Protoconid, Paraconid, Metaconid, Hypoconid. In the upper teeth, on the other hand, embryogenesis has been found to contradict the conclusions reached by the tritubercular theory or palingenesis, for all authors have agreed that the order is Paracone, Metacone, Protocone, instead of Protocone, Paracone, Metacone. When these facts were first brought out by Taeker, Röse and others, the writer, with undiminished confidence in the force of palæontological evidence, advanced as an explanation the fact that the protocone had become secondarily reduced in the upper molars, and that the embryogeny no longer recapitulated the order of evolution. This explanation has received a measure of support in the latest researches by

Woodward, in which it is shown that in those Insectivora *in which the protocone is still the most prominent cusp of the superior molars, this cusp also appears first in embryogeny,* the paracone and metacone following. Woodward points out that this is not the case in other Insectivora, for they agree with the Primates, Ungulates and other types which have been carefully investigated, in the late appearance of the protocone. Woodward infers from these conflicting facts that there were two modes of

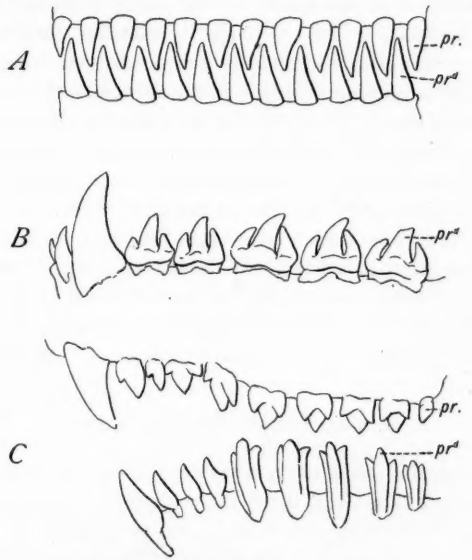


Fig. 4.—THE THREE PRIMARY FORMS.
A. Haplodont, of the Dolphin.
B. Triconodont (? Secondary) of the Seal, *Leptonyx.*
C. Tritubercular of the Cape Mole, *Chrysochloris.*

cusp evolution within the order Insectivora, one in which the protocone appeared first, and another in which the protocone appeared third or last. Such a double genesis seems to the writer highly improbable.

It is, however, certainly important, as Woodward and many others have observed, to strengthen the palæontological evidence for the tritubercular theory. The writer has recently

made strenuous efforts to secure additional evidence, which have not thus far been successful. In the meantime too great emphasis cannot be laid upon the fact that *all the existing palæontological evidence points in the same direction*, namely, to the presence of the chief cone upon the inner side of the upper molars, and upon the outer side of the lower molars. An important oversight on the part of those who are still unconvinced of the tritubercular theory, is the necessity of a mechanical adaptation of the upper to the lower teeth in every stage of development, which is perfectly met by the tritubercular theory. Given the universally acknowledged *trigonid* or triangular arrangement of cusps in the lower teeth, no mechanical relations can be imagined in an upper molar crown which originated with the external cusps, paracone and metacone.

If the main object of palæontological research is to trace back various lines of descent as far as possible, the very unity of primitive type makes this apparently more difficult than before, but not really so. We were working before upon a false basis, or no basis at all; we can now advance upon the certain basis of primitive form and the one requisite of progress is to employ much more exact methods of description and analysis.

1. THE THREE PRIMARY FORMS.

So far as the molar teeth were concerned, there were, to our present knowledge, but three great primary forms, which succeeded each other as stages and also persisted. From one or other of these all the known recent or fossil mammalian teeth have diverged, including probably the Multituberculates. These types are illustrated in the accompanying cut. First, the *haplodont* crown, which links the mammals with the reptiles; second, the *triconodont* crown which was predominant in the Lower Jurassic period; third, the *tritubercular* crown which appeared in the Lower Cretaceous[1] and has been by far the most productive. The transitions between these great types

[1] It now appears advisable that the so-called Como (Atlantosaurus) Beds of North America and the Purbeck Beds of England should be placed in the base of the Cretaceous instead of in the Upper Jurassic as formerly.

are found among the Mesozoic mammalia and have already been worked out with considerable care.

From each of these great primary stages it would at first appear that some of the mammalia directly derived their dental type, for both the "haplodont" and "triconodont" crowns are seen to-day among the Cetacea. Yet there is ground for uncertainty here, for as the progressive stages are "haplodont," "triconodont," "tritubercular," so the retrogressive stages reverse this order, passing from "tritubercular" back to "triconodont" then into "haplodont." Another view therefore is that such primary forms have been secondarily acquired. The apparently "triconodont" lower molar of *Thylacinus* is, for example, an indirect retrogression from a tritubercular ancestral form. Again, among the aquatic carnivora, in the series of molars of the Seals, the eared Seals and the Walruses, we see the backward stages from the "triconodont" to the "haplodont;" and it is therefore probable that the "tritubercular" was the form of molar possessed by the Pinnipedia when they diverged from the Fissipedia. There is considerable evidence that a similar retrogression has simplified the

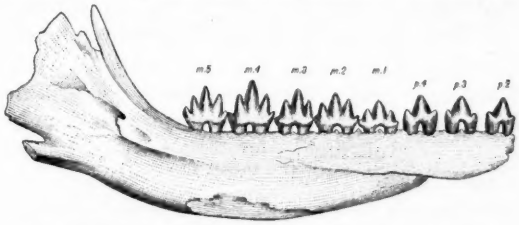


Fig. 5.—Amphilestes, a Jurassic triconodont, primary.

molar crowns of modern Edentates, for it is now certain that at least the Gravigrada were descended from tritubercular ancestors, the Ganodonta. Again, among the Cetacea, all their oldest allies, such as *Zeuglodon*, are triconodont, not haplodont. With both these groups, therefore, there are therefore the possibilities of direct or of retrogressive origin of the "triconodont" molar.

This uncertainty hardly extends to the "triconodont" stage, which is typically shown in the lower Jurassic *Amphilestes*,

Phascolotherium and the later *Triconodon.* It is a very significant fact that this type dies out in the Upper Jurassic. It is true we find many more recent "triconodont" teeth, the lower molar of *Mesonyx* for example, which are positively known to be of tritubercular origin. Richard Owen compared the lower molars of *Thylacinus* with those of *Triconodon,* but we have found that what appeared to him to be similar cusps are not really homologous. Thus while it is possible that the ancestors of some of the modern haplodont and triconodont mammals never reached the tritubercular stage, it is by no means a settled fact. On the other hand, excepting the isolated group of Multituberculates and the single genus *Dicrocynodon* Marsh, *the molars of every known fossil mammal from the close of the Lower Cretaceous until the close of the Eocene period bear the tritubercular stamp.*

This would appear to support the generalization that all mammals passed through the third primary or tritubercular stage, yet it must be borne in mind that all our evidence is derived from inhabitants of fresh water basins, and that the persistent haplodont and triconodont types may have been living contemporaneously in the seas.

But the Multituberculates and Monotremes, were they tritubercular in origin? The teeth of *Ornithorhynchus* are so degenerate and irregular that many features of primitive form may be lost; they may quite as readily be interpreted as tritubercular as multitubercular, especially in the embryonic stage as described by Poulton.

It is not difficult however to establish the principle that a true multitubercular tooth may spring from a tritubercular tooth. As pointed out elsewhere, my friend, Prof. J. A. Allen, directed my attention to the "multituberculate" rodents. A comparison of *Mus, Dipodomys* and *Perognathus* beautifully illustrates the stages between "trituberculy" and "multituberculy" in living types. The three rows containing twelve tubercles in the later genus are derived respectively from the "external," "intermediate" and "internal" cusps of a sexituberculate bunodont type similar to the *Hyracotherium* molar on a small scale. The additional cusps are successively added to

each row. Thus the upper molar of *Perognathus* is closely analogous to that of the Mesozoic Multituberculata, especially to such a type as *Tritylodon*. Passing also from the higher Multituberculata to the lower and more ancient, we find fewer and fewer cusps until we reach a "paucitubercular" parent form in the upper Triassic *Microlestes*. *Microlestes* itself was not tritubercular; it had a basin-shaped crown surrounded by irregular tubercles; this basin, however, was not dissimilar to that in molars of the Eocene rodent *Plesiarctomys* which is obviously of tritubercular origin.

This evidence has been recently reinforced in a most striking manner by the discoveries of Professor Seeley in the Karoo Beds of South Africa, from which two principal conclusions may be derived: First, that *Tritylodon*, formerly placed with the mammalia, contains a large number of reptilian characters. Since the fossil is closely related on the other hand to the re-

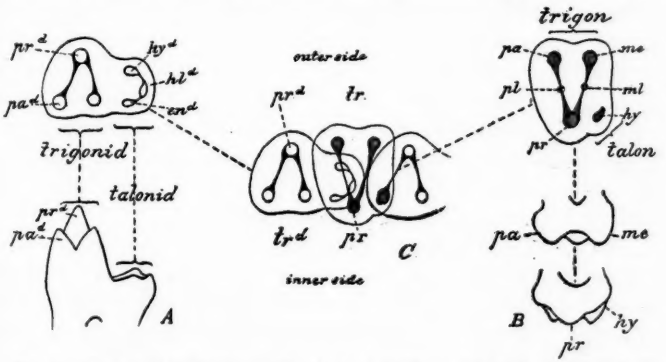


Fig. 6.—TRIGON AND TALON. Mechanical relations of tritubercular molars; also homologous and functionally analogous parts.

maining Multituberculata, it appears possible that we have in the *Gomphodontia* the group from which the Multituberculates sprang. A study of the dentition of other Theriodonts in the Karoo Beds shows that while *Tritylodon* and *Trirachodon* are typically Multituberculates, others, such as *Diademodon* have a trituberculate pattern, exactly such a pattern as we find in certain Lower Eocene mammals. Altogether there is certainly

increasing support for the writer's hypothesis, that the multituberculate tooth is of tritubercular origin.

2. THE EARLY STAGES OF SEXITUBERCULY.

The Trigon.—Respect for Cope's priority should not prevent our ultimately adopting the late Professor Rütimeyer's term *trigonodont* for the third stage, retaining the term "tritutubercular" as descriptive of the whole transformation, and as peculiarly appropriate to certain types of teeth, such as the superior molars of the lemurs. "Trigonodont" is most appropriate because the first step in molar morphology is to identify the "primitive triangle," and the term "tubercular" hardly applies to a lofty pointed cutting crown. Our studies among the Mesozoic mammals have left no doubt that the upper and lower triangles, or "trigon" and "trigonid," were derived from the reptilian protocone by the addition of lateral cusps. The mechanical perfection of this type consisted in the fact that the lateral cusps were developed upon or shifted to the outer side in the upper molars, and to the inner side in the lower molars, thus producing an interlocking "shear." The "trigon" was essentially a cutting apparatus, so perfect that many mammals retained it without further evoluiton. Thus *Chrysochloris*, the little Insectivore of the Cape, presents a fine example of this type, persistent in its molars. (See Figure 4).

The Talon.—But in the great majority of trituberculates the "talon" was added as a crushing apparatus. It invariably appeared first in the lower molars (where we may distinguish it as the "talonid") and pressed into the basin of the superior "trigon." At first it was a mere spur (hypocone) as in *Amphitherium* or in the existing *Calcochloris* (allied to *Chrysochloris*), but between the Jurassic and Upper Cretaceous periods the talonid widened into a basin-like shelf supporting an outer cusp, the "hypoconid;" an intermediate cusp, the "hypoconulid," and an inner cusp, the "entoconid." Thus we find in the majority the Upper Cretaceous (Laramie) and Puerco or lowest Eocene mammals that the lower molars bear six cusps; the above-mentioned three on the talonid and three on the trigonid (protoconid, paraconid, metaconid). With these six

cusps the equipment of the lower molar was complete, and it was ready for transformation into the molar of a primate, ungulate or carnivore, as the case might be.

But why notice such a detail as the posterior intermediate cusp or hypoconulid? Because, to give only two reasons, this

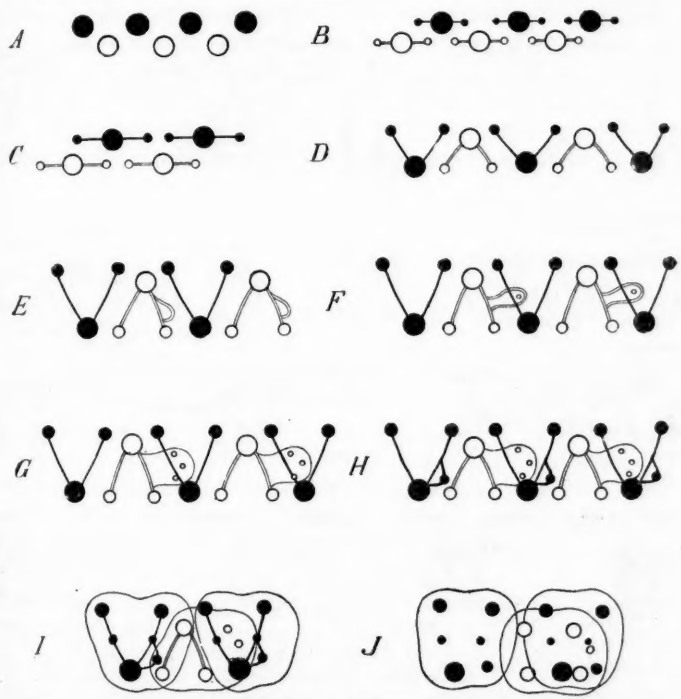


Fig. 7.—Phyletic and Mechanical History of the Molar Cusps.
A. Reptilian stage, Haplodont, Permian. *B.* Protodont stage (*Dromatherium*) Triassic. *C.* Triconodont stage (*Amphilestes*). *D.* Tritubercular stage (*Spalacotherium*). *E.* Tritubercular-tuberculo sectorial, Lower Jurassic. *F.* The same, in Upper Jurassic. *G.* The same, in Upper Cretaceous. *H.* The same, Puerco, Lower Eocene. *I.* Sexitubercular-sexitubercular, Puerco. *J.* Sexitubercular-quadritubercular, Wahsatch.

cusp plays an important rôle in the ungulates; it is invariably present, except perhaps in the Coryphodons, and forms the third lobe of the last lower molar, which is thus proved to be

a primitive character. Again, it is found throughout all the Primates, and although seldom availed of, this cusp constitutes an important and distinctive character as between the different races of man. Its extreme antiquity is appreciated by few anthropologists, and at the present time it is degenerating. (See Figure 8).

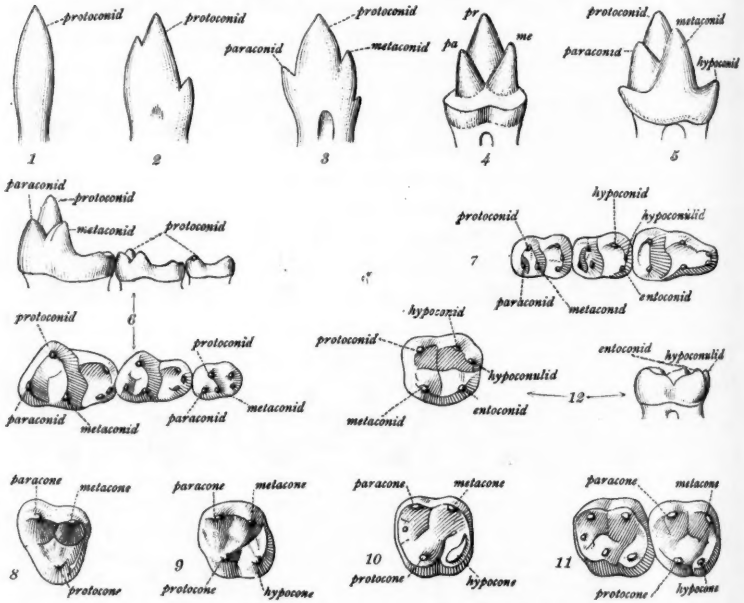


Fig. 8.—Epitome of the Evolution of the Human Molar Teeth. 1. Reptile. 2. Dromatherium. 3. Microconodon. 4. Spalacotherium. 5. Amphitherium. 6. Miacis. 7–8. Anaptomorphus. 9–12. Various Primates 11–12. Homo. A succession of molar *types*, not of ancestral types.

While these changes were taking place, the upper molars remained comparatively stationary in the persistence of the simple trigon, up to the close of the Cretaceous period, the main change being a depression of the level of the trigon. All three cusps in some groups were depressed from the high secodont to the low bunodont level. In the majority of the carnivorous types we find that only the protocone was de-

pressed and that the pair of outer cusps, paracone and metacone, persisted on their high primitive level; the crown being thus prepared for the transformation into the true "sectorial." But in the omnivorous and herbivorous types, all three cusps are depressed and the upper molars always increased their crushing area by the addition of a heel or "talon," exactly analogous to that previously developed upon the lower molars. As is well known, this "hypocone" is an upgrowth from the cingulum and its typical mode of development is well shown in the Primates (Fig. 9). While this was going on, the trigon was also supplementing its bunodont equipment

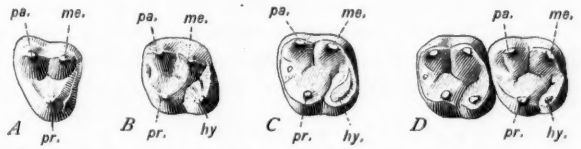


Fig. 9.—Superior molars of Primates, Anaptomorphus to Homo, showing evolution of *hypocone*, *hy*, from the cingulum.

by the addition of the little intermediate cusps "protoconule" and "metaconule." These always appeared where the "talonid" abuts against the "trigon." Thus, finally, the upper molar, like the lower, was provided with six cusps and both were ready to diverge into any ungulate form.

All these foregoing stages persist and may be readily studied and verified among some of the living marsupials, insectivores, lemurs and monkeys, and can be seen in any well-equipped osteological museum almost as well as among the fossil series.

THE NOMENCLATURE OF THE MOLAR CUSPS AND CRESTS.

The system proposed by the writer some years ago has now been adopted by many of the American, English and German writers who are studying the fossil series. It is based upon simple principles:

1°. The termination "*-cone*" is employed for all the primary central cusps derived from the crown of the tooth, while the

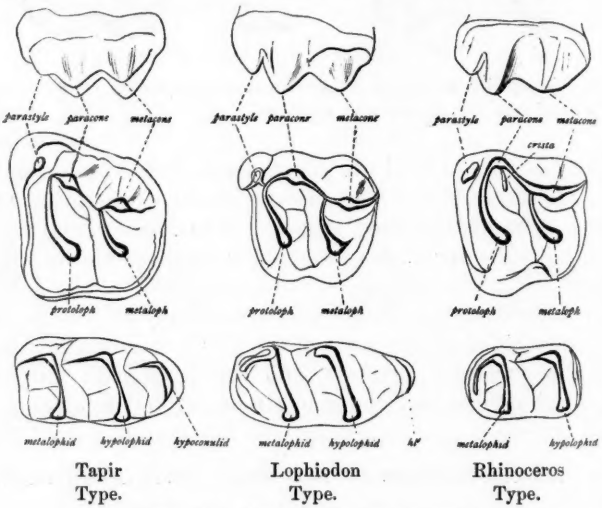
diminutive *-conule* is employed for the smaller "intermediates" or cuspules.

2°. All peripheral cusps or elements developed mainly from the cingulum or external borders of the crown are distinguished as *-styles* ("pillar" or "buttress"). The only exception is the "hypocone," which, while arising from the cingulum, soon takes its place upon the crown.

3°. The crests, transverse and longitudinal, are always composed of two or more cusps and styles, and are distinguished by the termination *-loph.*

4°. The prefixes "*proto-*," "*para-*," "*meta-*," "*hypo-*," "*ento-*," etc., refer back to the primitive position or order of development in the triconodont and tritubercular stages.

5°. The suffix *-id* is employed arbitrarily to distinguish the elements of the lower molars from those of the upper.



Tapir Type. Lophiodon Type. Rhinoceros Type.

Fig. 10.—Modelling of the Cusps.

The use of the terms "trigon" and "talon" for the cutting and crushing regions of the crown, respectively, is especially advantageous among the the upper Mesozoic and lower Cainozoic mammals, where it is necessary to refer constantly to the

relations of the upper and lower crowns in apposition, as in the evolution of the sectorial and lophodont types. As to the form of the cusps, we pass from simple pointed cusps to three well known modes of modification to which the adjective "bunoid," "lophoid," and "selenoid" may be applied. A combination of these terms gives us a permanent system of distinguishing the complex forms of ungulate molars from each other, by referring first to the form of the protocone; second, to that of the outer paracone and metacone. Thus in *Palæosyops*, as the protocone is bunoid and the outer cusps are selenoid, the crown may be distinguished as "buno-selenodont." In *Palæotherium* the protocone is "lophoid," and it may be described as "lopho-selenodont." *Rhinoceros* is truly "lophodont," since all its six cusps are "lophoid." These are preferable to the terms "tapirodont," "symborodont," "bathmodont," "loxolophodont," etc., proposed by Cope, because the latter are associated with generic types.

THE EVOLUTION OF THE UNGULATE MOLAR.

The fact of derivation of all ungulate molars (excepting in the Amblypoda) from sexitubercular upper and lower crowns, leads us to look sharply for traces of these six tubercles from the primitive plan of *Euprotogonia*. These six cusps are almost invariably found in the upper molars of both perissodactyls and artiodactyls up to the middle of the Eocene period, as typified in *Hyracotherium* and *Homacodon* or *Dichobune*. In the lower molar the trigon loses the "paraconid" and the talon loses the "hypoconulid," the latter persisting only in the last molar as the "third lobe." This loss was accompanied by the complete transformation of the lower molars from the "secodont" to the comparative "bunodont" type, as effected in the lowering of the "trigonid" to the level of the "talonid." This is exemplified in the steps between the first and third molars of the creodont genus *Miacis* (Fig. 8). In a side view of all early ungulate molars, such as *Hyracotherium*, we see that the "trigonid" is still the highest portion of the crown. In the ungulates, unlike the carnivores, all three molars were affected simultaneously. An exactly similar levelling pro-

cess can now be observed in a comparative series of recent Lemurs and Monkeys. To summarize the five steps toward the establishment of the ungulate primitive type: the addition of the lower talonid, the lowering of the cusps of the upper trigon, the addition of the upper talon and simultaneous lowering of the lower trigonid, the loss of the paraconid and hypoconulid. By these changes the cutting was transformed into the crushing type. The development of the talon necessitated the loss of the "paraconid," for they both occupy the same space when the jaws are closed; the stages of this gain to the upper molar and loss to the lower are well shown in the species of *Euprotogonia*.

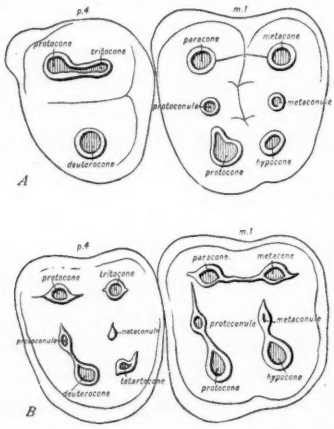


Fig. 11.—PREMOLAR TERMINOLOGY, PROPOSED BY SCOTT. Primitive Ungulate Types. Fourth upper premolar and first molar of *A. Euprotogonia*, and *B. Hyracotherium*.

All these changes belonged to the constructive period and took place presumably before the great divergence of the ungulate orders began; or it may have been partly due to paralellism or homoplasy, because we find that the molars of *Trigonolestes*, the earliest known artiodactyl, are tritubercular. Some groups, such as those to which *Coryphodon*, *Uintatherium* and *Periptychus* belong, built up their whole molar structure upon the tritubercular or trigonal basis.

From this point onward dated the period of "modernization." An important legacy of the old triangular form was the *oblique arrangement of the outer and inner cusps* parallel with the sides of the primitive triangles. Thus all the primitive crests developed upon these cusps were oblique and not directly transverse. The main features of modernization upon which we must now closely direct attention are:

1°. The addition of one or more peripheral cusps or "styles" as upgrowths from the cingulum. These reached their most extreme development in the *Equidæ*. (See Fig. 10.)

2°. The persistence or degeneration of the cingulum at certain points, for all primitive molars are completely invested by a broad cingulum.

3°. The modelling of the cusps into the "bunoid," "lophoid" or "selenoid" form.

4°. The metatrophic or unequal growth of the cusps, especially as affecting the external pair, protocone and metacone, in the upper molars.

5°. The shifting of the cusps from their primitive position upon the crowns.

6°. The shifting point of union of these transverse crests with the external crest.

The differential features of the development of ungulate molars all group around these six heads. If we were examining an isolated molar tooth from the lower Eocene, the first step would be to locate its primary cusps and then note its divergence as tested by the above differentia. We would then be in a position to make a conjecture as to the series in which this molar belonged—as no two series are modified similarly in all these respects. Yet the prevailing method among many palæontologists is to pass lightly over most of the differentia and, for example, group widely divergent forms under the *Lophiodontidæ* as if in the constitution of these dense enamelled tissues nature could lightly pass from one to another.

A few words now upon the secondary "styles." Their function is evidently to increase and elaborate the crushing surface of the crown. In *Phenacodus* the first to appear is the "mesostyle" between the paracone and metacone, but this genus was on a side line of the *Condylarthra*. In all true perissodactyls and artiodactyls, the first peripheral cusp to appear is the antero-external buttress of the upper molars, which we call the "parastyle," since it adjoins the paracone. The "mesostyle" appears later, and only in those ungulates in which the paracone and metacone are moulded into crescents. Thus the lower Eocene *Hyracotherium* does not exhibit this cusp, but it

appears as a distinctive feature of the middle and upper Eocene *Pachynolophus* (Orohippus). The mesostyle was strongly developed in all the selenodont, buno-selenodont and lophoselenodont types, such as the Artiodactyla and *Meniscotherium, Chalicotherium, Palæosyops,* the palæotheres and horses. Look at an upper molar of *Merychippus* and see what an important rôle these styles play (Fig. 1). First, we observe the "parastyle" and "mesostyle," next most important is the "hypostyle," which develops near the hypocone upon the posterior cingulum of *Mesohippus* and *Anchitherium* and finally completes the border of the "anterior fossette" or cement lake. The horse molar, by the way, furnishes the best illustration of the value of tracing back the various portions of the crown to their birth-place in the primitive crown of *Hyracotherium.* Every turn in this labyrinth of folds is thus made perfectly clear.[1]

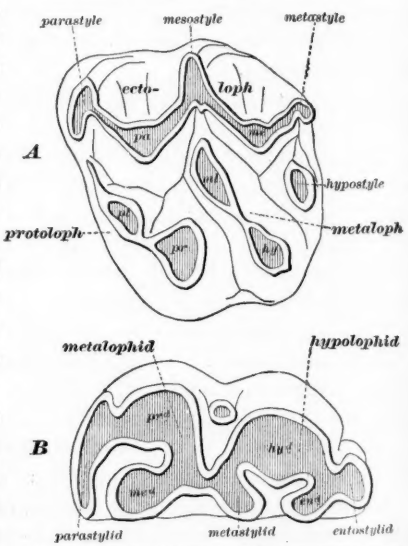


Fig. 12.—The Highest Development of the Styles. *A.* Upper molar of Horses, *Anchitherium* and *B. Merychippus.*

A corresponding set of styles grows up on the lower molars, and it is very easy to locate them with reference to the reciprocal upper set if we simply keep in mind the fact that throughout the whole course of development the elements of each trigonid are placed just in front of those of the corresponding trigon, that is, the protoconid and metaconid fit just

[1] Mr. Lydekker has courteously called attention to the fact that in the earlier study of this subject the writer misinterpreted the descriptive terms employed by Huxley.

in front of the paracone and protocone, as shown in the diagram (Fig. 6). Thus the inferior entostylid is developed near the entoconid, while the superior hypostyle develops near the hypocone. The first of the inferior styles to develop is the "metastyle," a reduplication of the metacone, the well known "a-a" of Rütimeyer.

In all ungulates in which the "mesostyle" is developed the external cusps remain of the same size. In the tapirs no "mesostyle" appears, yet these cusps are symmetrical; but in the rhinoceroses, which also lack the mesostyle, the first fact to note is the asymmetrical growth of these cusps; the metacone is elongated while the paracone is reduced and crowded up against the parastyle. This point was observed by Cope in seeking for a definition of the Rhinocerotidæ in 1875. The rhinocerotine molar, whether of *Hyrachyus, Amonodon* or *Aceratherium*, has the further distinction that it is the only type in which a complete ectoloph is formed, and second, as Cope has already observed, the asymmetry of the external cusps is emphasized by the flattened metacone and conic paracone. Figure 2 illustrates also the three projections from the ectoloph, protoloph and metaloph, namely, the "crista," "antecrochet" and "crochet." These, with the three "fossettes" formed by them, were noted and named by Cuvier, and, as shown by Falconer, Flower, Lydekker and others, are of great specific value.[2] We have already seen that Cuvier's term "fossette" may be substituted for the "cement lakes" in the horse's molar. The terms formerly adopted, or proposed, by Lydekker[3], after English usage, and those in German and French usage, have already been given in the Table

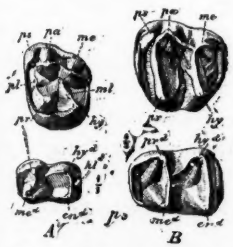


Fig. 13.—Tapir Molars. Primitive *Systemodon*, and modern *Tapirus*.

[2] As pointed out by Lydekker, the writer mistakenly transposed these terms "crochet" and "antecrochet" in a former paper, Bull. Mus. Comp. Zool., 1890, p. 81.

[3] "Siwalik Rhinocerotidæ," Pal. Indica.

There is another line of perissodactyls in which the metacone is flattened but not elongated, and no complete ectoloph is formed. I refer to the little Wasatch genus *Heptodon* (which Cope has erroneously placed in the ancestry of *Hyrachyus*), also *Helaletes* of the Bridger, an undoubted successor of *Heptodon*, which Marsh was wrongly led to consider an ancestor of the Tapirs. The molars, studied by our six differentia, are found to differ from those of the rhinocerotine *Hyrachyus* by the incomplete ectoloph, also by the shifting inwards of the metacone and consequent shortening of the metaloph. In looking about for molars with similar differentia, we find those of the true *Lophiodon* of Europe, *L. isselense*, for example, stand nearest.

Now, how shall we distinguish the early Tapirs? First, there is no mesostyle; second, the paracone and metacone (as observed by Cope) are both conic and symmetrical; third, a feature of great importance, apparently unnoticed hitherto, is that the protoloph and metaloph spring from the anterior bases of the paracone and metacone, and not from near the apices of these external cusps as in all molars of rhinocerotine affinity. We find, as a general law, that where the external cusps are symmetrical as in Palæotheres, Horses and Tapirs, the transverse crests always arise in front; where they tend to asymmetry as in Helaletes, Lophiodon and Rhinoceros, the crests tend to rise from or near the apices.

Enough has been said to make clear the new method of procedure in the analysis and discrimination of early ungulate molars. Let us apply this form of statement and description to the aberrant lower Wasatch genus *Meniscotherium* as a resumé:

Upper Molars, buno-selenodont; paracone, metacone and protoconule selenoid; metaconule reduced, lophoid, united with hypocone; a large parastyle and mesostyle. *Lower Molars*, seleno-lophodont; metaconid reduplicated by metastylid. We find that a similar analysis may be given of *Chalicotherium*, excepting only "protoconule reduced." It is thus suggested that *Meniscotherium* may be related to *Chalicotherium*.

This method may be summarized as follows: Look for traces of *primitive* ancestral structure in the form and position of the cusps. Second, determine the divergent form, position, proportions and relations of the cusps. Third, determine the secondary cusps, crests and foldings, their form and relations. Finally, let us turn to a wholly different molar type and examine the complex and aberrant molars of *Coryphodon*. Can we establish any homologies between its elements and those of any of the ungulates we have been considering? Fortunately we are partly guided by the molar of the Puerco genus *Pantolambda* Cope, which is even older than the Coryphodons. This is our key to the ancestral or primitive form, and by its aid Cope has, we think, rightly interpreted the homologies of the Coryphodon molar elements. We first note that nature has here evolved a lophodont crown from the tritubercular or trigonal basis, for there is no distinct talon or hypocone except in the unique form *Manteodon*. *Pantolambda* has no parastyle, but a prominent mesostyle and a pair of selenoid external cusps, also a selenoid protocone with a spur leading toward a proto-

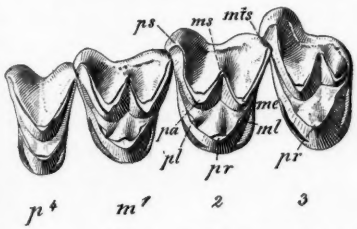


Fig. 14.—Molars of *Pantolambda*, the ancestor of *Coryphodon*.

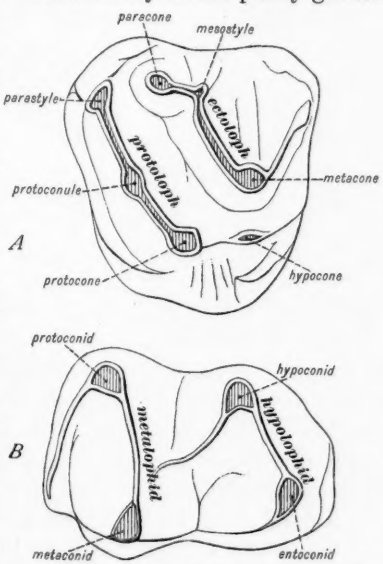


Fig. 15.—Molars of *Coryphodon*, showing shifting of the Crests.

conule and suggesting an incipient protoloph. The selenoid external cusps of this type suggest a comparison with the lopho-selenodont perissodactyls, and we are able to reach the following result.

In a large series of *Coryphodon* molars we see first that the protoloph is formed of the protocone, protoconule and parastyle, exactly as in the horses. Unlike the horse (Anchitherium), the ectoloph is more or less detached from the protoloph, but the examination of a large series of specimens in the American Museum and Cope's collection convince us that it is composed of the same elements as in *Anchitherium*, namely, the paracone, which has almost lost its crescentic form, the mesostyle, which is much less prominent, and the metacone, which is still crescentic. This enables us to describe this molar as follows: It is of buno-selenodont origin and has a complete protoloph and ectoloph, *but no metaloph.* Its homologies with the elements of the Anchitherium molar are clearly shown by a comparison of Fig. 12 and Fig. 15. This illustrates again the necessity of starting upon the trigonal basis instead of upon the basis of two lobes, as in the work of French palæontologists. In his "Enchainements du Monde Animal," Prof. Gaudry has admirably worked out the upper molars of the perissodactyla and artiodactyla from the sexitubercular stage onwards. He divides the tooth into two lobes, a "premier lobe," including our protocone, protoconule and paracone and a "second lobe" including our hypocone, metaconule and metacone. All subsequent authors in France follow this system, which indeed works well for one group. But what we need now is a system which will apply not only to all groups of ungulates, but to unguiculates as well, so that when we reach the upper Cretaceous borderland between unguiculates and ungulates we can employ the same set of terms and the same basis of description.

I can only conclude by expressing the conviction that the tritubercular theory of Cope rests upon such conclusive evidence that its universal adoption as the key to the interpretation of all molar teeth cannot be long deferred. It is one of the chief anatomical generalizations of the present century.

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BIOLOGICAL STUDIES IN MASSACHUSETTS. NO. 3.

By George C. Whipple.

GEOGRAPHICAL DISTRIBUTION OF MICROSCOPICAL ORGANISMS.

The geographical distribution of the various microscopical organisms is not only an important subject, but it is an extremely vexatious one. A great deal of study has been given to it, but we are yet very far from understanding this as well as other laws governing this kingdom. Why it is that these organisms grow vigorously in one pond and are at the same time absent from a neighboring one where the conditions are apparently as favorable, or why it is that they suddenly appear in ponds where hitherto they have never been seen, we are unable to say. Solution of these problems can only be accomplished by long continued observation and experiment, and by the working out of the life history of each particular organism. The following statistics are of some value in connection with this

subject as they show the relative abundance of the different classes of organisms in some of the important surface water supplies of Massachusetts, together with some of the elements of the sanitary chemical analyses.

For the purpose of this comparison 57 ponds and reservoirs were selected where monthly examinations, both chemical and biological, have been carried on for a number of years by the State Board of Health. The results of these examinations were carefully studied and the ponds (which, for convenience, we may consider to include lakes, ponds and storage reservoirs) divided into groups as shown in Table 4.

The first two columns in this table give the names of the ponds and the cities which they supply. The third gives the depth of the pond, whether shallow or deep. The next four columns show the relative abundance of the four most important classes of organisms, namely, Diatomaceæ, Chlorophyceæ, Cyanophyceæ and Infusoria. The four groups are characterized as follows: and the group to which each pond belongs is indicated by a number.:

Group I. Number of organisms often as high as 1000 per c. c.

Group II. Number of organisms only occasionally as high as 1000 per c. c.

Group III. Number of organisms ordinarily between 100 and 500 per c. c.

Group IV. Number of organisms never above 100 per c. c.

These figures refer not to the numbers present in the average sample of water, but to the numbers during the season of maximum growth. The boundaries of the groups were not sharply defined, and in a number of cases it was hard to tell whether a pond should be classed in group II or III. The last five columns show the ponds divided into classes according to some of the elements of the chemical analysis, namely, color, excess of chlorine, hardness, albuminoid ammonia (in solution), free ammonia and nitrates. In each case four classes are given, division being made according to the schedule given at the bottom of the table.

TABLE No. 4.

CLASSIFICATION OF FIFTY-SEVEN MASSACHUSETTS PONDS AND RESERVOIRS.

The figures refer to the classes to which the ponds belong.

City or Town	Pond or Reservoir	Depth	Diatomaceæ.	Chlorophyceæ.	Cyanophyceæ.	Infusoria.	Color.	Ex. of Chlorine.	Hardness.	Alb. Amo. (dis.)	Free Ammonia.	Nitrates
Abington,	Big Sandy Pond	0	3	4	4	3	1	3	1	2	1	2
Andover	Haggett's Pond	0	3	3	4	2	1	3	3	3	1	1
Ashburnham	Upper Naukeag Pond	0	4	4	4	3	1	1	1	1	1	1
Athol	PhillipstonReservior	0	3	2	2	3	2	2	2	2	2	2
Boston	Reservoir No. 6	+	3	4	4	3	3	3	3	3	2	1
Boston	Reservior No. 4	+	3	3	4	4	3	2	3	4	2	2
Boston	Reservior No. 2	0	3	3	2	4	4	3	3	3	2	2
Boston	Reservior No. 3	0	1	3	2	3	3	3	3	4	3	3
Boston	Lake Cochituate	+	1	3	3	3	1	3	4	2	2	3
Boston	Farm Pond	0	3	3	3	1	1	3	3	3	2	3
Boston	Mystic Lake	+	1	1	3	1	1	4	4	3	4	4
Boston	Jamaica Pond	+	1	1	1	3	1	4	4	3	4	4
Brocton	Salisbury Brook Reservoir	0	1	3	4	3	3	2	2	4	2	2
Cambridge	Fresh Pond	+	1	2	2	3	1	4	3	3	4	4
Cambridge	Stony Brook Reservoir	0	1	3	3	2	3	3	3	3	3	3
Danvers	Middleton Pond	+	3	3	4	3	3	2	2	3	1	2
Fitchburg	Scott Reservior	+	1	3	4	3	1	2	2	2	1	1
Fitchburg	Falulah Reservior	0	1	3	3	3	1	2	2	2	1	2
Fitchburg	Meeting House Pond	0	4	4	4	3	1	2	2	2	1	1
Gardner	Crystal Lake	+	3	4	4	3	1	3	3	1	2	2
Gloucester	Dikes Brook Reservoir	0	2	3	4	4	2	1	1	3	3	1
Gloucester	Wallace Pond	0	3	4	4	3	3	2	2	4	2	1
Gloucester	Fernwood Lake	0	2	4	4	3	4	2	2	4	3	2
Hingham	Accord Pond	+	1	3	4	3	1	3	1	1	1	1
Hingham	Fulling Mill Pond	0	1	3	3	3	1	3	3	1	4	3
Hinsdale	Storage Reservior	0	2	2	4	3	2	1	2	2	1	1
Holyoke	Whiting Street Reservoir	0	2	3	2	1	1	2	4	3	1	3
Holyoke	Ashley Pond	0	1	4	4	3	1	2	4	3	2	2

Hudson	Gates Pond	+	3	3	3	3	1	2	2	2	2	2
Leominster	Haynes Reservoir	0	1	2	2	3	2	1	1	4	3	2
Lynn	Breeds Pond	0	1	3	3	3	2	2	3	3	3	2
Lynn	Birch Pond	0	1	3	3	2	2	2	3	4	3	2
Lynn	Walden Pond	0	1	2	1	1	3	1	2	4	4	2
Lynn	Glen Lewis Pond	0	1	1	1	1	3	1	2	4	4	2
Malden	Spot Pond	+	2	2	3	3	1	3	4	3	3	2
Marlboro	Lake Williams	0	3	2	3	3	1	3	3	3	1	2
Montague	Lake Pleasant	+	3	4	4	4	1	2	1	1	2	2
Nantucket	Wannacomet Pond	0	3	3	3	2	1	1	3	4	2	2
Natick	Dug Pond	+	2	3	3	3	1	4	4	3	3	4
New Bedford	Lake Quittacus	0	4	3	3	4	4	2	2	3	2	3
North Brookfield	Doane Pond	0	3	3	4	2	3	3	3	4	3	2
Norwood	Buckmaster Pond	0	2	4	4	1	1	3	2	3	3	2
Orange	North Pond	0	2	3	4	3	3	3	2	3	2	1
Plymouth	Little South Pond	0	4	3	3	3	1	1	1	2	2	1
Quincy	Storage Reservoir	0	1	2	2	3	4	3	2	2	3	3
Rockport	Cape Pond	0	1	3	2	3	1	3	3	3	1	1
Salem	Wenham Lake	+	1	3	3	3	1	3	4	2	2	2
Springfield	Ludlow Reservoir	0	1	1	1	2	2	2	3	4	3	2
Taunton	Assawamsett Pond	0	3	4	4	4	2	3	2	2	1	1
Taunton	Elders Pond	0	4	4	4	4	1	8	1	2	1	1
Westborough	Upper Sundra Reservoir	0	3	2	2	3	2	3	1	3	3	1
Winchester	North Reservoir	0	1	2	1	1	1	4	4	3	3	3
Winchester	South Reservoir	0	3	3	3	3	2	2	4	4	3	2
Winchester	Middle Reservoir	0	4	3	1	3	3	3	3	4	3	1
Woburn	Horn Pond	+	1	1	1	1	2	4	4	4	4	4
Worcester	Lynde Brook Reservoir	0	3	2	2	3	1	2	3	2	3	2
Worcester	Tatnuck Brook Reservoir	0	1	3	3	3	2	1	2	2	2	2

DEPTH. + Deep
0 Shallow

ORGANISMS. 1. Often above 1000 per c.c.
2. Occasionally above 1000 per c. c.
3. Usually from 100 to 500 per c. c.
4. Below 100 per c. c.

COLOR. 1. 0 to 0.30 Nessler Scale.
2. 0.30 to 0.60 Nessler Scale.
3. 0.60 to 1.00 Nessler Scale.
4. 1.00 to —— Nessler Scale.

EXCESS OF CHLORINE, 1. 0
2. .01 to .03
3. .04 to .25
4. .25 to

HARDNESS. 1. 0 to 0.5
2. 5 to 1.0
3. 1.0 to 2.0
4. 2.0 to

ALBUMINOID AMMONIA (dissolved) 1. 0 to .0100
2. .0100 to .0150
3. .0150 to .0200
4. .0200

FREE AMMONIA. 1. 0 to .0010
2. .0010 to .0030
3. .0030 to .0100
4. .0100 to

NITRATES. 1. 0 to .0050
2. .0050 to .0100
3. .0100 to .0200
4. .0200

The figures of the chemical analyses are given in parts per 100,000.

If we consider the ponds with reference to the growths of organisms, we obtain from the above table the following summary:

TABLE No. 5.

Group	Number per c. c.	Number of Ponds and Reservoirs			
		Diatomaceæ.	Chlorophyceæ.	Cyanophyceæ.	Infusoria.
I	Often above 1000 per c. c.	24	5	7	8
II	Occasionally above 1000 per c. c.	8	11	10	7
III	Usually between 100 & 500 per c. c.	19	29	18	35
IV	Below 100 per c. c.	6	12	22	7

From this it appears that the Diatomaceæ are the organisms most commonly found in large numbers. There are 24 ponds (42 per cent of the ponds considered) which often have these organisms as high as 1000 per c. c., while in only 6 (11 per cent) are they always below 100 per c. c. The Chlorophyceæ are not often found in great abundance, though many ponds contain them in moderate numbers. Only 5 ponds (9 per cent) have growths of 1000 per c. c., while 29 (70 per cent) have growths of from 100 to 500 per c. c. The Cyanophyceæ are not as common as the Chlorophyceæ, but where they do occur their growth is usually greater and they cause more trouble. There are 7 ponds (12 per cent) that commonly have growths above 1000 per c. c., while in 22 (39 per cent) they are never above 100 per c. c. The Infusoria are somewhat more abundant than either the Chlorophyceæ or Cyanophyceæ. 8 ponds (12 per cent) often have growths above 1000 per c. c.; 35 ponds (60 per cent) have growths between 100 and 500 per c. c.

From Table 4 it also appears that 28 ponds (49 per cent) often have high growths of one or more of these classes of organisms at one time or another during the year. Such growths, except in the case of certain diatoms, are almost always noticeable and frequently are very troublesome. In seventeen ponds the Diatomaceæ alone reach 1000 per c. c.; in one pond the Cyanophyceæ alone; and in three ponds the Infusoria alone. One pond has high growths of Diatomaceæ,

Chlorophyceæ and Infusoria; two of Diatomaceæ, Chlorophyceæ and Cyanophyceæ; two of Diatomaceæ, Cyanophyceæ and Infusoria. In two ponds all four classes are found in large numbers. There is but one pond where the organisms never rise above 100 per c. c.; there are sixteen where no class of organisms shows numbers greater than 500 per c. c.

For the purpose of determining whether the depth of the pond exercises any important influence upon the growth of the organisms the following table has been compiled. Ponds reported as having a maximum depth of more than 30 feet have been called "deep ponds," and those having a less maximum depth "shallow ponds." This arbitrary dividing line was selected after considering the relation between the maximum and the average depth, the temperature changes at various depths, and the depth to which the water is kept in circulation by the wind. In a general way it may be said that the shallow ponds are those in which the water is kept in vertical circulation by the wind over the greater part of their area and for the greater portion of the year, while the deep ponds exhibit the phenomena of stagnation over a considerable portion of their area.

TABLE NO. 6.

Depth	Number per c. c.	Number of Ponds			
		Diatomaceæ.	Chlorophyceæ.	Cyanophyceæ.	Infusoria.
Deep	Often above 1000 per c. c.	8	3	2	2
Deep	Occasionally above 1000 per c. c.	2	2	1	0
Deep	Usually between 100 & 500 per c. c.	6	8	6	12
Deep	Always below 100 per c. c.	0	3	7	2
Shallow	Often above 1000 per c. c.	16	2	5	6
Shallow	Occasionally above 1000 per c. c.	6	9	9	7
Shallow	Usually between 100 & 500 per c. c.	13	21	12	23
Shallow	Always below 100 per c. c.	6	9	15	5

There are 16 deep and 41 shallow ponds. Of the deep ponds 63 per cent at times have growths of the Diatomaceæ above 1000 per c. c., while of the shallow ponds 54 per cent have such growths. There are no deep ponds where the Diatomaceæ are lower than 100 per c. c., while 15 per cent of the shallow ponds have them lower than that figure. It

thus appears that the heavy growths of the Diatomaceæ are somewhat more likely to be found in the deep than in the shallow ponds. The same may be said of the Chlorophyceæ, though the difference is not so marked. 31 per cent of the deep ponds and 27 per cent of the shallow ponds at times have growths as high as 1000 per c. c. The Cyanophyceæ and Infusoria, on the other hand, incline towards shallower water. In the case of the former, 18 per cent of the deep ponds and 34 per cent of the shallow ponds at times have growths of 1000 per c. c., while in the case of the latter the figures are 12 per cent and 32 per cent respectively.

In this connection it would be of interest to show statistically the relation that undoubtedly exists between the growths of organisms and the character of the material forming the bottoms of the ponds, but unfortunately the necessary data is lacking in too many cases. So far as observations have been made, however, it appears that muddy bottoms are very largely responsible for the excessive growth of microscopical organisms.

An important question, and one which is of particular interest to water analysts, is the relation between the growths of organisms and the chemical analysis of the water in which the organisms are found. Unquestionably there is such a relation, and we should very much like to be able to take up a chemical analysis and say "this water contains such and such substances in solution, and, therefore, such and such organisms may be expected to thrive well in it." In other words, we desire to know better the nature of the necessary food supply of the microscopical organisms.

The following tables are designed to show in a very general way the relation between the organisms in our 57 selected ponds and some of the important elements of the chemical analysis. These bring out several important facts.

First, it is seen that the color of a water has an important influence upon the number of organisms that will be found therein. Of the 24 cases where the Diatomaceæ are commonly found higher than 1000 per c. c., 12 (or 50 per cent) occur in light colored waters, i. e., water having a color lower than 0.30

Table No. 7.

Chemical Analyses (parts per 100,000).		Number of Ponds and Reservoirs in which Diatoms are			
		Often above 1000 per c. c.	Occasionally above 1000 per c. c.	Usually between 100 & 500 per c. c.	Below 100 per c. c.
Color (Nessler Scale)	.0 to .30	12	4	9	4
	.30 to .60	6	2	4	0
	.60 to 1.00	6	1	5	1
	1.00 to ——	0	1	1	1
Excess of Chlorine	0	4	2	1	2
	.01 to .03	8	1	8	2
	.04 to .25	8	3	10	2
	.25 to ——	4	2	0	0
Hardness	0 to .5	2	1	3	3
	.5 to 1.0	7	4	5	2
	1.0 to 2.0	8	0	10	1
	2.0 to ——	7	3	1	0
Albuminoid Ammonia (dissolved)	0 to .0100	2	0	2	1
	.0100 to .0150	6	1	5	3
	.0150 to .0200	8	6	7	1
	.0200 to ——	8	1	5	1
Free Ammonia	.0000 to .0010	3	2	5	3
	.0010 to .0030	6	1	10	2
	.0030 to .0100	8	5	4	1
	.0100 to ——	7	0	0	0
Nitrates	0 to .0050	3	3	5	6
	.0050 to .0100	11	3	13	0
	.0100 to .0200	6	2	1	0
	.0200 to ——	4	1	0	0

Table No. 8.

Chemical Analysis (parts per 100,000).		Number of Ponds and Reservoirs in which the Chlorophyceæ are			
		Often above 1000 per c. c.	Occasionally above 1000 per c. c.	Usually between 100 & 500 per c. c.	Below 100 per c. c.
Color (Nessler Scale)	0 to .20	2	5	14	8
	.30 to .60	2	4	5	1
	.60 to 1.00	1	2	8	2
	1.00 to ——	0	0	2	1
Excess of Chlorine	0	1	3	4	1
	.01 to .03	1	2	11	5
	.04 to .25	0	4	13	6
	.25 to ——	3	2	1	0
Hardness	0 to .5	0	2	3	4
	.5 to 1.0	1	4	8	5
	1.0 to 2.0	1	3	13	2
	2.0 to ——	3	2	5	1
Albuminoid Ammonia (dissolved)	0 to .0100	0	0	2	3
	.0100 to .0150	0	4	7	4
	.0150 to 0200	2	5	12	3
	.0200 to ——	3	2	8	2
Free Ammonia	0 to .0010	0	2	7	4
	.0010 to .0030	0	1	13	5
	.0030 to 0100	2	5	8	3
	.0100 to ——	3	3	1	0
Nitrates	0 to .0050	0	2	8	6
	.0050 to .0100	2	6	13	6
	.0100 to .0200	0	2	7	0
	.0200 to ——	3	1	1	0

Table No. 9.

Chemical Analysis (parts per 100,000).		Number of Ponds and Reservoirs in which the Cyanophyceæ are			
		Often above 1000 per c. c.	Occasionally above 1000 per c. c.	Usually between 100 & 500 per c. c.	Below 100 per c. c.
Color (Nessler Scale)	0 to .30	2	4	12	11
	.30 to .60	2	3	4	3
	.60 to 1.00	3	2	1	7
	1.00 to ——	0	1	1	1
Excess of Chlorine	0	2	1	3	3
	.01 to .03	1	3	5	10
	.04 to .25	1	5	8	9
	.25 to ——	3	1	2	0
Hardness	0 to .5	0	2	1	6
	.5 to 1.00	2	2	4	10
	1.00 to 2.00	2	5	7	5
	2.00 to ——	3	1	6	1
Albuminoid Ammonia (dissolved)	0 to .0100	0	0	1	4
	.0100 to .0150	0	3	6	6
	.0150 to .0200	2	5	8	7
	.0200 to ——	5	2	3	5
Free Ammonia	0 to .0010	0	2	1	10
	.0010 to .0030	0	2	9	8
	.0030 to .0100	3	5	6	4
	.0100 to ——	4	1	2	0
Nitrates	0 to .0050	1	2	1	12
	.0050 to .0100	3	4	10	10
	.0100 to .0200	1	3	5	0
	.0200 to ——	2	1	2	0

Table No. 10.

Chemical Analysis (parts per 100,000).		Number of Ponds and Reservoirs in which the Infusoria are			
		Often above 1000 per c. c.	Occasionally above 1000 per c. c.	Usually between 100 & 500 per c. c.	Below 100 per c. c.
Color (Nessler Scale)	0 to .30	5	2	20	2
	.30 to .60	1	3	6	2
	.60 to 1.00	2	2	8	1
	1.00 to ——	0	0	1	2
Excess of Chlorine	0	1	2	5	1
	.01 to .03	1	2	13	3
	.04 to .25	2	3	15	3
	.25 to ——	3	0	3	0
Hardness	0 to .5	0	0	7	3
	.5 to 1.00	3	0	12	2
	1.0 to 2.0	1	6	10	2
	2.0 to ——	4	1	6	0
Albuminoid Ammonia (dissolved)	0 to .0100	0	0	4	1
	.0100 to .0150	0	0	13	2
	.0150 to .0200	5	2	12	3
	.0200 to ——	3	4	7	1
Free Ammonia	0 to .0010	1	1	9	2
	.0010 to .0030	1	1	13	4
	.0030 to .0100	2	5	10	1
	.0100 to ——	4	0	3	0
Nitrates	0 to .0050	0	1	12	3
	.0050 to .0100	3	4	17	3
	.0100 to .0200	3	2	3	1
	.0200 to ——	2	0	3	0

on the Nessler scale, and none occur in water where the average color is above 1.00. The same fact is noticed in the case of the other organisms, but not as strongly emphasized as with the Diatomaceæ. The reason for this is doubtless on account of the difference in specific gravity between the diatoms and the other organisms. The diatoms, by reason of their silicous cell walls are heavy, while the other organisms not only are much lighter, but some of them liberate gas, causing them to keep near the surface. Being thus kept near the surface, the depth to which light penetrates in a body of water makes less difference with the growth of the Cyanophyceæ, for example, than it does with the diatoms, which constantly tend to sink, and which are kept near the surface chiefly by the vertical currents in the water.

The "excess of chlorine" means the difference between the amount of chlorine found in a sample of water and that found in the unpolluted water of the same region. To a certain extent it represents the amount of pollution which the water has received. It is important to know whether this element of the analysis bears any relation to the organisms and whether one may rightly infer that a large growth of organisms in a reservoir is any indication of the pollution of a water supply. A study of the tables shows that only to a small extent does the excess of chlorine influence the number of organisms observed, though there is a slight tendency for heavy growths of organisms to accompany high excess of chlorine. This fact corresponds with the common observation that vigorous growths of organisms are often observed in ponds far removed from any possible contamination.

The hardness of a water, i. e., the abundance of carbonates of calcium and magnesium, appears to have some influence upon the organisms. This is noticed in all four classes, though it is most marked in the case of the Diatomaceæ and Infusoria. For example, of the 10 ponds low in hardness not one ever has the Infusoria as high as 1000 per c. c., while of the 11 ponds high in hardness not one but that has Infusoria above 100 per c. c., and 4 of them commonly have them above 1000 per c. c.

The sanitary chemical analysis ordinarily states the amount of nitrogen present in four different forms, namely, albuminoid ammonia (dissolved and suspended), free ammonia, nitrites and nitrates, which represent four stages in the change of organic to inorganic matter. Since nitrogen is essential to all living matter we naturally expect that organisms will thrive best in waters rich in that element. Our statistics show that this is the case, and that it is true for each class of organisms and for the different conditions of nitrogen tabulated. The free ammonia and nitrates appear to be particularly influential in determining the amount of life present. For example, 10 of the 13 ponds low in free ammonia never show maximum growths of the Cyanophyceæ above 100 per c. c., while 4 of the 7 ponds high in free ammonia commonly have growths above 1000 per c. c.

One must be careful in these matters, however, not to mistake cause for effect. Free ammonia, for example, indicates organic matter in a state of decay, and instead of representing the food of the organisms in question it may represent their decomposition. The interaction of the various organisms is a very complicated question, and to what extent one species lives upon the products of decay of another is not well known. The food supply of the different organisms can only be determined by experiments made upon pure cultures, and this subject is as broad as the host of the microscopical organisms is numberless. For a long time we have been groping in darkness, but the active interest which is awaking in the study of the plankton gives us hope to believe that light has begun to dawn.

HAMMAR'S ECTOPLASMIC LAYER.

By E. A. Andrews.

Twenty years ago Selenka observed and figured a connection between the outer parts of the cells in cleaving eggs of several Echinoderms, but it remained for Professor Hammar to point out, in 1895,[1] the great significance of this intercellular structure.

In the sea urchin, *Echinus miliaris*, he found a thin outer coat that did not take part in cleavage, but remained as a continuous envelope over all the cells. This he interpreted as an ectoplasmic part of the egg, as a living connection between the cells, and as such of greatest import in understanding the interactions of cells in cleavage and in throwing light upon the divergent results of recent experimental work upon cleaving eggs. This, he thought, might be that organic intercellular connection potulated as probable by Whitman, Wilson and others.

Proof, however, of the living nature of this layer seems wanting; the figures of preserved sections raise a question as to how far the result may be due to or affected by the reagent used; and that the layer has a structure somewhat like an alveolar layer of Bütschli indicates, but does not prove, that the layer was actually living substance.

Later, E. B. Wilson[2] stated that he had, in the main, verified Hammar's results upon sea urchin eggs, presumably upon preserved material also.

The same objection may be raised against accepting all the results subsequently obtained by Hammar,[3] for though he found the outer ends of the cleaving cells of the eggs in Cœlenterates, Annelids, Molluscs, Arthropods and Tunicates connected by a thin line of substance, and though a similar connection is shown in the epithelium of young vertebrate embryos, yet the

[1] Archiv. f. Mik. Anat., V, 47.
[2] The Cell, p. 43. Macmillan Co., N. Y.
[3] Archiv. f. Mik. Anat., 49.

nature of the methods employed, the use of corrosive sublimate solution to shrink the cells apart save at the outer surface, raises grave suspicion as to the real nature of this outer connection.

Some observations upon living eggs of Lamellibranchs seem, however, to strengthen the position assumed by Hammar and to make it probable that the intercellular connection observed by him is, in some cases at least, really a living ectoplasma.

It is well-known that eggs frequently present a clear outer protoplasm that forms a true ectosarc over the more granular, yolk bearing interior part. In the eggs of the Lamellibranch, *Nucula delphinodonta*, this is very marked. Here the ectosarc rises up into waves and also into blunt pseudopodia-like papillæ, as seen under oc. 8. obj. 4 mm. These waves and processes change shape in such a way as to leave no doubt of the living nature of this ectosarc. In one case the ectosarc extended all over the polar body, so that it was included as a bubble might be escaping through a film of jelly, and a clear stalk or base of ectosarc was left between the egg and the polar body. But as these eggs were probably never fertilized and did not develop, the above phenomena may well have been abnormal.

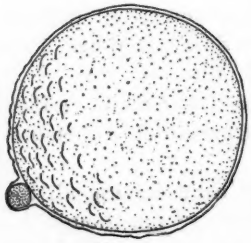

FIG. 1.

Yet in another Lamellibranch, *Angulus tener*, much the same was seen: figure 1, drawn from camera sketches of the living egg with oc. 4, obj. 2 mm., indicates the ectosarcal waves and a polar body buried in the ectosarc that surrounds it. In the two-cell stage marked ectosarcal waves rise up like frills on each side of the cleavage plane. When these cells divide to make four, the ectosarc is seen to follow the groove as it sinks down, figure 2, and not to leave the surface as Hammar described in Echinus. When the actual cleavage plane cuts

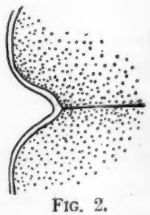

FIG. 2.

across the cell it does not affect the ectosarc which thus remains continuous from one cell to the other, figure 2. When the four cells formed flatten out against one another, figure 3, the ectosarc is continuous all over the egg, and not cut by the cleavage planes. That this is still a living ectosarc seems to be shown by the waves that rise up in it, especially over the smaller cells where they may be very high and sharp.

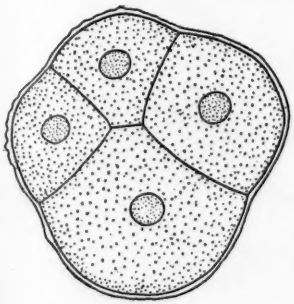

FIG. 3.

Similar waves were seen in the one cell stages of Yoldia, and may be common enough in Lamellibranchs. Thus Professor Brooks, in 1880,[4] called attention to contraction waves in the egg of the oyster. His figures indicate a clear outer layer continuous over all the cells in various stages of cleavage, and, apparently, continuous with the polar bodies which adhere together, and to this layer up to a late stage of cleavage, *and in spite of the fact that a membrane is thrown off early in the cleavage.* It would seem necessary to interpret this layer as a living, membrane-forming substance, though with the low powers used, the wavy appearance figured was interpreted as being a wrinkling produced by contractions "which travel rapidly toward the formative pole, near which they disappear" (p. 42). These wrinkles vanished in about fifteen seconds, but came again upon other cells later in cleavage. It seems probable that further study will show that such waves are largely due to contractions in the ectosarc itself, as they seem to be in the cases I have examined with higher powers.

The connection between such ectosarcal portions of the Lamellibranch egg and the ectoplasmic layer of the Echinoderm egg is indicated by the appearance seen in figure 4. This represents a surface view of the opening into the cleavage cavity of a four-cell stage of the Echnius common at Ros-

[4] Development of the American Oyster. Report of the Commissioners of Fisheries of Maryland, 1880.

coff, France, and was drawn from a *preserved* egg with camera lucida, oc. 18 and obj. 2 mm. A thin film of broken vesicular appearance stretches across the cleavage pore from one cell to the other, and is continuous with the surfaces of the cells, except where they arch down between the cells and on the sides of the cleavage pore. This film is absent, or broken, over part of the cleavage pore and beneath it are certain linear structures to be mentioned later.

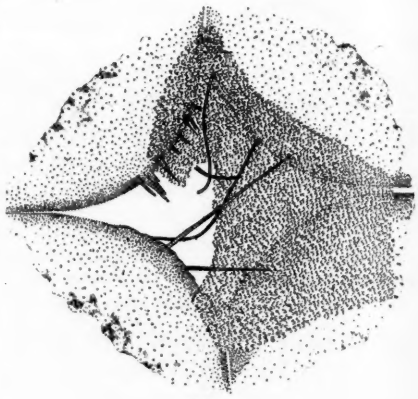

FIG. 4.

The peculiar official appearance of the layer makes it highly probable that it was a living ectosarcal substance extending from one cell to others. As such it seems the same as the continuous ectosarc of the Lamellibranch. It would appear to be the same thing seen by Hammar in Echinoderms both in section and in surface view—"In der Interstitien der Zellen kann man unter günstigen Umständen das abgehobene Ectoplasma auch im Flächenbild zum Gesichte bekommen" (1, p. 16).

We would conclude that the *living, ectosarcal,* membrane-like connection between the outer parts of cleavage cells actually exists in some eggs, whether in all the cases claimed by Hammar is still in doubt.

Another form of intercellular connection has been described by G. F. Andrews[5] in the cleaving eggs and larvæ of sea urchins and star fish; namely, fine filaments of living substance that are spun out from one cell to another much as a filose Rhizopod might connect with another by means of its delicate pseudopodia.

[5] Some Spinning Activities of Protoplasm. Journal of Morphology. Vol. XII, 1897.

Figure 4 indicates the difference between the two modes of intercellular connection as seen in *preserved* material, where, however, the threads are fewer, thicker and otherwise altered by the Killing fluid and by subsequent treatment. Beneath the outer film of connecting substance and on various levels, (some quite far down), very definite protoplasm-like threads extend out from a cell and crossing the cleavage cavity become continuous with the surface of some other cell. These filaments have a characteristic shape, mode of origin, insertion, structure and size. They are the altered remnants and representatives of the living filaments seen in the live egg. Besides the long filaments the specimen shows pseudopodia-like processes or tufts of threads, arising from one of the four cells. These came upward toward the membrane-like expanse and seemed to be continuous with it, so that the filamentous substance and the filmy expanse appeared to have been one common material.

In life the filaments are subject to flow and to change, and the same *may* be true of the ectosarcal expanse.

Though the filamentous and the membranous connections of cleaving cells seem so different, it is not improbable that they are both expressions of the same contractile powers in the ectosarcal part of the egg cell, and they both serve to make the living material continuous from one cell to another.

In the living eggs of representatives of widely separated groups of animals we thus see reasons for believing that the process of cleavage does not isolate the cells as much as has been thought; either the cells remain connected from the first and are but areas in a common mass of living material, or they may make and break connection with one another by living filaments, formed as fast as cleavage tends to organize the egg into cell areas. In preserved material we see remnants of such connections, and it becomes probable that such connections will be found throughout the animal series.

With the ever increasing knowledge of intercellular bridges in animals and in plants, and the recently demonstrated fact that in Echinoderms these bridges are used as means of transportation, that the filaments allow material to pass from one

cell to another, being, like Gromri's pseudopodia, *unstable sensitive, conductive, contractile,* we are on the road to admit not only the existence of such statical ectosarcal connections as Hammar discovers, but to accept as working hypothesis a conception of these bridges as dynamical factors of the greatest importance.[1]

A NORTH AMERICAN FRESH WATER JELLY FISH.

By Edward Potts.

On June 10, 1880, the first known fresh water jelly fish (*Limnocodium sowerbii*, Allman & Lankester) was discovered in the Victoria Regia tanks in Regent's Park, London. Near the end of November, 1884, a primitive "hydriform organism" from which it was supposed the jelly fish might have been derived, was found in the same tanks and described by Alfred Gibbs Bourne.[2]

About two months after Mr. Bourne's discovery, I first detected *Microhydra ryderi* upon some stones collected the previous autumn from the rocky bed of Tacony Creek, a rapidly flowing mill stream near Philadelphia, Pennsylvania, a small affluent of the river Delaware, but far above tide level. Some peculiarities in its structure and mode of gemmiparous multiplication were described by my valued friend the late Dr. John A. Ryder.[3]

Dr. Ryder had not, at the time of writing the above paper, seen the living organism which he there described. Specimens were, however, some years later, placed in his hands for study and watched for many months with exceeding interest. His early death has left in the possession of his representatives many excellent drawings and some valuable micro-slides as the only evidences of his interest and labor. No descriptive

[1] The Living Substance. G. F. Andrews. Boston: Ginn & Co., 1897.

[2] Proceedings of the Royal Society, Dec. 11, 1884, Vol. 38, p. 9, etc. See also paper by F. A. Parson, Jour. of Queckett Club, 2nd series, vol. 2, 1885–6.

[3] American Naturalist, Extr, Dec., 1886, p. 1232, etc.

text has been found, and the sorrow that his many friends feel at his early removal, has, to me, this added regret—that he was not able to complete an investigation, which, not unnaturally, perhaps, I felt to be of so great importance; and that he cannot now share with us our great delight in witnessing the further development from *Microhydra ryderi* of a "medusiform adult stage."

As may be seen by a comparison of the papers above named, all of them preliminary and incomplete,—there are obvious points of resemblance as well as of difference between these minute organisms that appeared, almost simultaneously, at geographical points so widely distant. The supposition that the form observed by Mr. Bourne is the earlier condition of Limnocodium is, of course, greatly strengthened by my actual observation of the budding and separation of free-swimming Medusæ from *M. ryderi*.[1]

We read that the specimens of Limnocodium often, perhaps generally, disappeared from the tanks about the end of June or July.[2] It is greatly to be regretted that the glass jars containing my species were not carefully examined throughout June and July of the present year, during which period there may have been a larger production of maturing jelly fish. On the first day of August, however, my attention was arrested by the spasmodic contraction of an evident Medusa in the above-mentioned jar, and, during several following days, Prof. E. P. Cheyney and myself, on frequent occasions, watched the swelling buds upon colonies of *Microhydra* that had attached themselves to the glass. We witnessed the spreading of the disc, disclosing, from the first, eight marginal tentacles, a well-defined velum, whose aperture was from one-third to one-fourth the diameter of the disc, and a manubrium depending, about one-half the height (or depth) of the bell. Violent pulsating spasms finally resulted in an entire separation from the hydroid and the free life of a roving medusa. I kept no record of numbers, but it is believed that from twelve to twenty were seen.

[1] This alternation and progression may have been seen, later, in England, but I shall have to plead ignorance of the fact.

[2] In one case "swarms" are reported Aug. 18, 1882, at Kew Gardens.

Measurements were difficult, but as nearly as I could make it out, the jelly fish was, at this time, about one-thirty-second of an inch in diameter. It was of a somewhat prolate dome-shape, and when seen from the polar aspect, the manubrium had a clearly quadrate appearance, from whose corners or lobes four radial canals curved downward to the marginal canal. At every point of junction occurred a single tentacle, and another of equal size was found midway between them. These eight tentacles (the only number as yet observed), always pendent, were plentifully charged with thread cells, and, while susceptible of much variation in length, were not seen much longer than one-half the diameter of the disc.

As to temperature, it is obvious that the water of the jars in which this Medusa was developed, must have had nearly that of the surrounding atmosphere, with its diurnal changes, say from 60° to 85° at this season: during the winter, in our heated rooms, the temperature is probably more uniform. The hydroid form, in Tacony Creek, being but a few inches below the surface, must be subjected frequently to a temperature at or below the freezing point.

It is quite improbable that under the present artificial conditions, any Medusæ will attain full maturity this season. It is therefore manifestly unsafe to compare their minute size and general appearance with the totally dissimilar drawings given us of *Limnocodium*, where the latter had attained a diameter of about one-half an inch. The full life-history of the organism must, therefore, be again left imperfectly recorded; but I am happy to be able to state that my friend, Dr. Charles B. Davenport, of Harvard University, has consented to undertake the further technical study of it from material we have recently collected; and the drawings, etc. left by Dr. Ryder and to hope that many points, now obscure, may, through his efforts, be solved.

To aid the search of others for this—probably the most primitive cœlenterate—it may be well to state that, in my experience, I have only found *M. ryderi* in a natural condition, living as a messmate among colonies of Bryozoa that may be considered almost perennial in habit, where its own disabili-

ties as a food collector, on account of local inertia and the total absence of tentacles, were supplemented by the life sustaining currents induced by its more active neighbors. These conditions are near Philadelphia furnished by *Urnatella gracilis* Leidy and *Pottsiella erecta* Kræpelin (*Paludicella erecta* Potts). I regret to be obliged to add that I am not aware that either of these has been collected in any other neighborhood.

Philadelphia, August 19th, 1897.

SOME OBSERVATIONS ON THE PHYSIOLOGICAL FUNCTION OF THE PYLORIC CÆCA OF ASTERIAS VULGARIS.

By Ellen A. Stone.

The size and position of the pyloric cæca of our common star-fish, *Asterias vulgaris*, indicate an organ of great importance, yet their physiological function has been surprisingly little touched upon in any of the standard text-books of zoology. The most we can learn from them is a confused notion that they secrete some digestive fluid, which, according to some authors, is of unknown function, while others state that it is probably the representative of the bile of higher animals.

Dr. Griffiths and Dr. Fredericq, however, have demonstrated in the European species, *Uraster rubens*, the presence of active digestive ferments.[1] Their results, together with the abundant material and opportunity for studying these organs in Asterias, suggested the following experiments, which were carried on at the Laboratory of Physiological Chemistry, Brown University, under the direction of Mr. Ralph W. Tower.

The experimental methods and results are embodied in the following observations:

A. Preliminary Examination of the Gland.

I. The Reaction of the Secretion.

Before making any examination for the ferment or ferments that might be contained in the secretion of the pyloric cæca,

[1] A. B. Griffiths, "Physiology of the Invertebrata," pp. 83-85.

the glands were first examined as to the nature of the reaction of this secretion, and this was found to be slightly acid since it produced a tinge of red in a neutral solution of litmus. This trace of acidity, however, was found to be due to some organic acid, since a neutral solution of tropaeolin 000, which is extremely sensitive to mineral acids, showed no change in color upon the addition of a small piece of the freshly crushed glands.

II. Examination for Leucine.

For the extraction of leucine, should any be present, the glands of several star-fishes were macerated with water and allowed to stand for some time. After filtering through cheese-cloth the filtrate was acidulated with acetic acid and boiled. A considerable coagulum of native albumen appeared, which was filtered off, and to the filtrate lead acetate added. The small precipitate was filtered off and sulphuretted hydrogen passed through the filtrate to remove the excess of lead. This precipitate was removed by filtration and the filtrate then evaporated to dryness. The residue was extracted with boiling alcohol, filtered and evaporated to a syrup. On standing, knots of crystals collected on the sides of the beaker which showed, by microscopic examination, the characteristics of very impure leucine. They could not, however, be certainly identified as such, since their quantity was insufficient to try Scherer's test. In all probability, however, if this method were applied to a number of glands sufficient to give a considerable yield of crystals, they could be purified and would undoubtedly prove to be leucine with probably some clusters of tyrosin.

B. Proof of the Non-Existence of Glycogen.

In determining whether the function of the pyloric cæca of the star-fish is more similar to that of the liver or to that of the pancreas of higher animals, one of the most reliable criteria would be the existence or non-existence of glycogen in the organ.

Therefore the cæca of about twenty living star-fishes were quickly removed and placed in boiling water where they were

allowed to boil for some time; the liquid was then filtered off and Pflüger's method for extracting glycogen[2] was carefully carried out. At the end of the process a portion of the resulting liquid gave with dilute iodine a very slight mahogany color, which seemed to indicate the presence of a little glycogen. But on boiling the remaining portion of the extract with dilute hydrochloric acid for half an hour, and then neutralizing with sodium hydrate, no substance was produced which would reduce Fehling's solution. The total amount of glycogen present in the glands of these twenty star-fishes must, therefore, have been very small, thus indicating that these organs do not possess a function characteristic of the true livers of higher animals. The following experiment also confirmed this view: Working upon the supposition that if glycogen were present in the pyloric cases, it would almost immediately be converted into glucose, the glands of several star-fishes were removed and allowed to stand in an open dish for about half an hour. At the end of that period a cold water extract was made of one portion while a hot water extract was made of another part. Both extracts were subjected to the test for glucose with Fehling's solution, and neither gave the slightest reduction, thus showing that the glands contained no glucose, and hence no antecedant of glucose in the form of glycogen.

C. Examination for Digestive Ferments.

I. Proteolytic Ferment.

In carrying out this examination the proteid used was coagulated egg albumen, which was experimented upon in the following manner:

The white of one boiled egg was cut into small pieces and placed in 1000 cc. of a mixture of a 1 per cent. solution of sodium carbonate (Na_2CO_3) and sodium bi-carbonate ($NaHCO_3$) to which was added 100 cc. of a fresh water extract of the pyloric cæca of the star-fish and the whole was digested for 48 hours at a temperature of 37°C, the medium being kept free from bacteria by the presence of thymol. At the end of this

[2] Pflüger's Archiv. für Physiologie, 1894, pp. 394-396.

period the albumen appeared considerably corroded and easily crumbled upon slight pressure between the fingers.

The substance was filtered and the filtrate then neutralized with dilute hydrochloric acid, upon which a slight precipitate of albuminate appeared. This was separated by filtration and the filtrate boiled, when a considerable coagulum of native albumen occurred. The native albumen was filtered off and the fluid then evaporated to about 300 cc.

To this concentrated fluid strong alcohol was added in considerable excess upon which a copious fine floculent precipitate of albumoses and peptones appeared which slowly settled to the bottom of the beaker. This precipitate was collected upon a filter and dissolved in 600–700 cc. of water. The precipitate completely dissolved, yielding an opalescent fluid which gave a strong xanthoproteic reaction and also a characteristic biuret test tending more strongly towards the rose-pink of a peptone. Ammonium sulphate was added to this solution in the form of crystals till the whole was completely saturated, and after standing for several hours a copious precipitate of albumoses gathered. This precipitate of albumoses was separated by filtration and the fluid was then treated with barium carbonate and barium hydroxide to precipitate the sulphate from the solution. After repeated treatments all the sulphate was finally precipitated and removed by filtration and the fluid was then boiled to a small bulk. About three volumes of strong alcohol were added and a fine floculent precipitate appeared which settled on standing. This precipitate was collected and dissolved in water, and the solution then gave the various characteristic reactions for peptones.

The first alcoholic filtrate was evaporated to a very small bulk, filtered and allowed to cool. After standing some time crystals of leucine and tyrosin were found upon microscopic examination, while the fluid also gave Hoffman's test for tyrosin.

At another time a set of parallel experiments was carried on in which equal amounts, by weight, of egg albumen were allowed to digest for an equal time with the same amounts of water extract of the glands, but under different circumstances.

Two portions were digested in a medium of 1 per cent. sodium carbonate and sodium bi-carbonate, the one at a temperature of 37° C., the other at a temperature of 21° C. Two other portions were digested in a medium of 3 per cent. Ditman's sea-salt solution; one at 37° C., the other at 21° C. Still a fifth portion was digested in a medium of 0.2 per cent. hydrochloric acid at 37° C. All media were kept free from bacteria by the presence of thymol. The native and derived albumins were removed in each case in the same manner and then the fluids were all evaporated to the same small bulk, 200 cc. To each, 600 cc. strong alcohol were added, and the albumoses and peptones thus precipitated were collected upon balanced filter papers and weighed in order to determine the relative amounts formed in the different digestive processes. The results showed that digestion had gone on most rapidly in the medium of sodium carbonate and sodium bi-carbonate, and moreover that it had gone on in this medium at a temperature of 37° C. more rapidly than at 21° C. This same relation held in the case of digestion in the sea-salt medium, that being the more rapid which was allowed to go on at the higher temperature. In the case of digestion in the acid medium, scarcely any albumoses and peptones were formed, showing that in so weak an acid medium even as 0.2 per cent, digestion was greatly retarded.

II. Diastatic Ferment.

For this examination a dilute starch paste was made with 3 grams of starch to 200 cc. of water. To each of two portions of this paste was added an equal amount of fresh water extract of the pyloric cæca. Both were allowed to digest, one at a temperature of 37° C., the other at 21° C. Within fifteen minutes the substance digesting at 37° C. showed, upon testing with iodine, the port wine color peculiar to dexterine and also reduced the copper of Fehling's solution. Within half an hour these same reactions were produced in the portion of starch paste digesting at 21° C. Somewhat later both portions showed the presence of maltose in giving a negative test with iodine and a reduction of Fehling's solution. In this

case, too, that portion which was digesting at the higher temperature showed the presence of maltose first.

The digestive process converted the starch no further than maltose, for even after digesting all night no test for glucose was obtained by Barfold's test (acidified copper acetate solution).

III. Fat-Splitting Ferment.

The presence of a fat-splitting ferment in the secretions of the pyloric cæca was proved by the fact that neutral olive oil, after being digested in the presence of thymol for same time, with a fresh neutral water extract of these cæca at a temperature of 37½° C., gave a decided acid reaction with litmus paper, thus showing that the neutral olein had been converted into free fatty acid and glycerine. A control portion of olive oil *alone*, which was submitted to the same digesting process under the same conditions, showed no acidity at the end of the experiment.

To sum up the conclusions that the results of the foregoing experiments seem to warrant, it seems that the pyloric cæca of the star-fish have no properties whatsoever—except, perhaps, their size and possibly color—which entitle them to a comparison with the liver of higher animals. On the contrary, however, they may be said to be closely related to the pancreas of the higher animals. Their secretion is abundant and contains three ferments :—

1. A Proteolytic ferment comparable to trypsin which acts best in a slightly alkaline medium, to good advantage in a neutral solution, but scarcely at all in an acid medium ; converting proteids into diffusible peptones and breaking down some of these even further into amido acids, as leucine and tyrosine.

II. A Diastatic ferment comparable to the diastatic enzyme of the pancreas which acts quite rapidly upon starch, converting it through the dextrines into maltose.

III. A Fat-splitting ferment comparable to that of the pancreas which breaks fats into their fatty acids and glycerine.

Upon these few but important and well-established facts it seems necessary, then, to abandon the old ground of charac-

terizing the pyloric cæca of the star-fish as of unknown function, and to advance so far, at least, as to characterize them as important digestive glands, very similar in function to the pancreas of higher animals.

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EDITOR'S TABLE.

The confusion in the popular mind in regard to what biologists mean by "acquired character" is shown in a recent article by Prof. Cesare Lombroso,[1] and more strikingly in an editorial, apropos of this same article, which appeared a short time ago in the *Boston Medical and Surgical Journal*.[2]

Lombroso cites a number of cases which he regards as furnishing proof of the inheritance of acquired characteristics. In speaking of the development of the well known mental traits of the modern Hebrews he says: "Here we have a series of acquired psychical characteristics which have become heredity. This, no doubt, is due to some extent to climatic influences—transportation to colder countries—but more particularly to selection by persecution, as only by activity and the appearance of meanness and sordidness could the Hebrews have been saved from the fierce persecutions against which bold resistance would have been of no avail. It is this fact that made these vices prevail, and that caused the extinction, little by little, of those qualities—courage, generosity and boldness—that would have been more harmful than useful under the particular conditions." Again, in speaking of American traits of character, Lombroso says: "It happens because a race among the most robust of Europe has been transported to different surroundings; and the struggle for existence—rendered fiercer in the wilderness and among hostile tribes—if it served to destroy the weaker, gave room for the greater development of the strong, in whom qualities, perhaps already existent in the pacific Briton, but not yet unfolded for lack of occasion, emerged in the new adaptations required for new adventures." One might almost suppose these sentences to have been

[1] Lombroso, C.: The Heredity of Acquired Characteristics. *The Forum*, October, 1897, pp. 200–208.

[2] *Boston Medical and Surgical Journal*, October 21, 1897, Vol. 137, No. 17, p. 427.

written by the most orthodox of neo-Darwinians. Nowhere in his paper does Lombroso offer any proof that the characteristics mentioned are not fortuitous variations. He takes it for granted that because a character is new and adaptive, that it is an acquired character become hereditary. There seems to be in his mind the very common confusion between the terms "new" and "acquired."

The editor of the *Boston Medical and Surgical Journal* is suffering from a much worse confusion of the terms, for he has not yet learned to distinguish between infection and heredity. When the medical profession has demonstrated that syphilis is not an infectious disease, we shall be ready to accept congenital syphilis as an acquired character that has been inherited. Besides other cases of this kind, the editor cites the case of a child born of a mother who had taken from eight to fourteen grains of morphine daily, commencing soon after marriage. The three preceding children had died soon after birth. In this case the child, a ten pound girl, on the third day became sleepless, pale and prostrate, and five minutes later died. What possible bearing can a case like this have upon the question of the inheritance of acquired characters? Knowing the effect of morphine upon the adult, it is far from surprising that a child that had been bathed in and fed on morphine from the moment of conception until birth, should show some results of such treatment. We may have here an acquired character, but the evidence of inheritance is absolutely nil. It is a case of poisoning, not of inheritance.

The report of the proceedings of the Annual Meeting of the Boston Society of Natural History[3] has been lying upon our table for some time. We are glad to note that Prof. Hyatt has nearly completed the descriptive part of his work on the Achatinellinæ of the Hawaiian Islands. It is to be hoped that this very complete collection of land shells purchased by the Society in 1890 from the Rev. J. T. Gulick, will soon be placed on exhibition. It is one that will be of the greatest interest to all students of evolution.

It is annouced, also, that considerable progress has been made upon the collection illustrative of "dynamical zoology," and it is gratifying to know that it will be put in place during the present year.

[3] Proceedings Boston Society of Natural History, Vol. 28, No. 2, p. 45-72.

General Notes.

GENERAL BIOLOGY.

The average Contribution of each several Ancestor to the total Heritage of the Offspring.[1]—We inherit not only from our parents but also from our grandparents to remote generations. The problem is: What proportion of the whole is, on the average, inherited from each generation?

In an earlier work, Galton, as a result of experiments on sweet peas, reached the conclusion that 50 per cent. of our qualities are on the average derived from our two parents, and he suggested the probability that 25 per cent. comes from our four grandparents, 12.5 per cent. from all our great-grand-parents, and so on, the sum being 100 per cent. thus accounting for the whole inheritance. The present paper brings the required proof of Galton's hypothesis.

The method of proof is noteworthy. Galton had access to pedigree records of 'Basset' hounds bred through twenty years. These exhibited only two color types—tricolor (T) and non-tricolor (N). There were 817 hounds of known color derived from parents of known color: 567 of these had all four grandparents of known color; and 188, all great-parents. Galton determined, for example, whether the proportion of T-progeny of a known ancestry corresponds to the law of contribution enunciated above. He separated the progeny into three lots; namely, those which have 2 T-parents, 1 T-parent or 0 T-parent; each of these may be subdivided into lots having 4, 3, 2, or 1 T-grandparent. Do the percentages of T-progeny in these lots accord with what we might calculate from the law? Let us take a case; there are 119 individuals which have 2 T-parents and 3 T-grandparents. What per cent. should be tricolor? The two T-parents should each determine 25 per cent. total, 50 per cent. Each of the 3 T-grandparents should determine $\frac{1}{4}\times 25$ per cent., 6.25 per cent., total 18.75 per cent. together 68.75 per cent. To this must be added the influence of the T-great-grandparents and earlier ancestors. The probable percentage of unobserved T-ancestors and hence of T-generating influence may be calculated on the assumption that the percentage of T-parents producing T or N progeny will be the same for unknown as for known generations. By an exten-

[1] Francis Galton: Proc. Royal Soc lxi, p. 401–413, 1897.

sive calculation, not necessary to reproduce here, Galton found that the totality of the ancestors of each T-grandparent determines the tricolor character of 4 per cent. of the progeny, and all the ancestors of each N-grandparent determines the T-characters of 2 per cent. of the progeny, so we must add to our sum 3×4 per cent.=12 per cent. for the 3 T-grandparents and 2 per cent. for the N-grandparent which gives the grand total of $68.7+12+2=83$ per cent. of the 119 progeny (or 99 individuals) which should be tricolor. As a matter of fact of the 119 individuals which had the ancestry in question 101 individuals were tricolor. Many comparisons between calculations and observations were made which agreed as well as this and thus confirmed the truth of the conclusion that we inherit on the average one-half of our qualities from our parents and half the remainder from each successive earlier generation of ancestors.—C. B. D.

Preformation vs. Epigenesis.—That the modern revival of the preformation—epigenesis controversy is resulting in a harmonious middle position through the application of the experimental method is a source of gratification as well to the believers in the application of this method to embryology as to those who desire the settlement of the dispute. Incidentally, however, these experiments are giving a clearer insight into the form-producing and form-maintaining factors. One of the latest contributions of this sort is that of Crampton who has described in the Annals of the New York Academy of Sciences, Volume X, experiments on isolated blastomeres of the Ascidian *Molgula manhattensis.* He finds that here, much as in the sea-urchin, the one-half blastomere undergoes a strictly partial cleavage, but rearrangements of blastomeres soon occur which tend to mask the partial nature of the development. Eventually a nearly complete larva of less than normal size and with defects in certain organs is produced. The missing half has been supplied by the cells already present. Thus there is here no pure epigenesis, no strict preformation, but a remarkable regulation phenomenon, as Driesch would say, by which the mutilated organism attempts, but not altogether successfully, to develop normally despite the unfavorable conditions.

Dissemination of organisms.—Experiments of Dr. Amedeo Berlese showing how insects and especially ants and some species of flies aid in the diffusion, preservation, and multiplication of yeasts, are described in a recent number of *Nature.*[3]

[3] Nature, Oct. 14, 1897, pp. 575–577.

It is shown that yeasts not only may be carried in the digestive tract of flies (as well as upon the external parts of the body) but that they actually multiply there. The belief is expressed that many yeasts ordinarily pass the winter within the digestive tracts of insects, rather than upon the surfaces of plants or in the soil.

A Plankton Note.—Another illustration of the abundance of certain small animals in the ocean is furnished in a letter from W. A. Herdman published in *Nature*.[3] While crossing the Labrador current at about long. 50° W. in the steamship Parisian the party were served with a copepod stew. The little crustacea were caught by pumping the water into the ship and straining it through silk nets. In this way it was easy to obtain a sufficient number to make a "respectable dish."

MINERALOGY.

New Minerals. Derbylite.—Hussak and Prior[1] give a full description of a new antimono-titanate of iron, of which they had given a preliminary notice.[2] The mineral, named Derbylite in honor of the distinguished geologist of Brazil, O. A. Derby, occurs in the cinnabar-bearing sands of Tripuhay, Minas Geræs, Brazil, and has also been found in place in certain muscovite schists in the near vicinity. Derbylite is orthorhombic, $\breve{a} : \bar{b} : c = 0.96612 : 1 : 0.55025$. Twins on 011. Fracture parallel to 001 but no good cleavage. Crystals minute, color pitch-black, lustre resinous, hardness about 5, specific gravity 4.530. Optical properties undeterminable on account of opacity. Composition probably $FeO, Sb_2O_5 + 5\ FeO, TiO_2$ neglecting small amounts of silica, alumina and alkalies.

Zirkelite.—Prior[3] gives a revised analysis of this new mineral[4]

ZrO_2	TiO_2	ThO_2	Ce_2O_3	$(Y_2O_3?)$	UO_2	FeO	CaO	MgO	Ignition	Sum
52.89	14.95	7.31	2.52	0.21	1.40	7.72	10.79	0.22	1.02	99.03

corresponding to the formula (approximately) RO.2 (Zr Ti Th) O_2.

[3] Nature, Vol. 59, p. 565, Oct. 14, 1897.

[1] Min. Mag., Vol. XI, No. 52, p. 176.

[2] Min. Mag., Vol. XI, No. 50, p. 85.

[3] Min. Mag., Vol. XI, No 52, p. 180.

[4] First described in Min. Mag., Vol. XI, No. 50, p. 88. See abstract this journal, Vol. XXXI, July, 1897, p. 601.

Wellsite, a new Zeolite.—Pratt and Foote[5] describe a new mineral found in the Buck Creek Corundum Mine, Clay Co., N. C. They name it wellsite in honor of H. L. Wells, Prof. of Chemistry in Sheffield Scientific School. It occurs together with chabazite on albite, rarely also on hornblende and corundum, these minerals constituting a vein in a large mass of dunite near its contact with gneiss. Wellsite is monoclinic, forming doubly-twinned crystals like those of harmotome with pseudotetragonal aspect. Twinning planes are c, 001 and e, 011. Forms observed c, 001; a, 001; b, 010; m, 110; $\dot{a} : \bar{b} : c = 0.768 : 1 : 1.245$ $B = 23° 27'$. Cleavage none, lustre vitreous, colorless or white, hardness 4–4.5, specific gravity varying between 2.278 and 2.366 probably depending on differences in the ratio of barium to calcium in different crystals. Double refraction positive and weak. Plane of optic axes at right angles to 010, the obtuse bisectrix inclined 52° to c in the obtuse angle. 2 E probably between 120° and 130°. Chemical composition:

SiO_2	Al_2O_3	BaO	SrO	CaO	MgO	K_2O	Na_2O	H_2O	Sum
43.86	24.96	5.07	1.15	5.80	0.62	3.40	1.80	13.35	100.01

corresponding to the formula $R\ Al_2Si_3O_{10} .3H_2O$. R contains BaO : CaO : $(Na_2O + K_2O)$ in the ratio of 1 : 3 : 2. It was found that the water appeared to be in three conditions in the molecule, one-third being given off between 100° and 200°, another third between 200° and 300°, and the remaining third only at a red heat. The relations of wellsite to the phillipsite group of the zeolites is shown in the following table:

		$\dot{a} : \bar{b} : c$	β
Wellsite	$RAl_2Si_3O_{10} .3\ HO.$	0.768 : 1 : 1.245	53 27
Phillipsite . . .	$RAl_2Si_4O_{12} .4\frac{1}{2}\ H_2O$	0·70949 : 1 : 1.2563	55 37
Harmotome . .	$RAl_2Si_5O_{14} .5\ H_2O$	0.70315 : 1 : 1.2310	55 10
Stilbite	$RAl_2Si_6O_{16} .6\ H_2O$	0.76227 : 1 : 1940	50 49

The authors predict the probable occurrence of a fifth member of the group corresponding to a hydrated anorthite which would have the composition $RAl_2Si_2O_8 \cdot 2\ H_2O$.

Silicate containing lead.—Penfield and Foote[6] describe a new mineral from the Franklin, New Jersey, zinc deposits to which they give the name roeblingite in honor of Mr. W. A. Roebling, the distinguished engineer of Trenton, N. J. Roeblingite occurs at the one thou-

[5] Am. J. Sci., Vol. CLIII, 1897, p. 443.
[6] Am. J. Sci., Vol. CLIII, 1897, p. 413.

sand foot level of the Parker shaft of the N. J. Zinc Company, on or near the contact between granite and white limestone. There are many minerals in the immediate vicinity especially garnet and axinite, in the cavities of which it is generally is found. It forms dense, white, compact masses consisting of an aggregate of minute prismatic crystals which were doubly refracting but whose crystal system could not be determined. Specific gravity 3.433, hardness a little less than 3. Chemical composition:

SiO_2	SO_2	PbO	MnO	CaO	SrO	K_2O	Na_2O	H_2O	Sum
23.66	9.00	31.03	2.48	25.95	1.40	0.13	0.40	6.36	100.32

corresponding to the complicated formula $H_{10}Ca_7Pb_2Si_5S_2O_{28}$, the small amounts of MnO, SrO and alkalies being united with the calcium. This is equivalent to $5H_2CaSiO_4+2CaPbSO_4$. This adds one to the small list of silicates containing lead and is the first observed occurrence of a sulphite in nature. Pyrognostics: fuses at 3 to a globule, giving blue lead flame and with soda a lead coating; Mn reaction; soluble in weak acids with separation of gelatinous silica.

Bixbyite.—Penfield and Foote[7] describe a new mineral from the topaz locality in the mountains, thirty-five miles southwest of Simpson, Utah. The crystals are implanted upon topaz and altered garnet and rhyolite and are evidently a product of fumarole action.

Bixbyite is isometric, crystallizing in cubes sometimes modified by the icositetrahedron, 112, the crystals being upwards of 5 mm. on the edge. Irregular fracture with traces of octahedral cleavage, color brilliant black with metallic lustre, streak black; hardness 6–6.5, specific gravity 4.945. Fuses at 4 and becomes magnetic; powder dissolves with difficulty in HCl, liberating chlorine. The analysis (by Foote) showed the following composition:

SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	MgO	O	Sum
1.21	2.53	47.98	1.70	42.05	0.10	4.38	99.95.

The silica and alumina are regarded as due to a small amount of topaz which could not be separated. The composition may then be expressed as R_2O_3 where R is Fe, Mn, and a little Ti. But other considerations, especially its isometric form, point rather to the formula $RO.RO_2$ or $FeO.MnO_2$ with small amounts of MgO and MnO replacing FeO, and TiO_2 replacing MnO_2. It thus corresponds closely to braunite, $MnO.MnO_2$ and to the isometric perofskite, $CaO.TiO_2$. The

[7] Am. J. Sci., Vol. CLIV, 1897, p. 105.

name is in honor of Mr. Maynard Bixby of Salt Lake City, who first brought the mineral to notice.

Associated with the bixbyite are topaz crystals showing combinations of the following forms:

a, 100; c, 001; m, 110; l, 120; d, 201; f. 021; y, 041; o, 221; u, 111.

There are also rough pseudomorph crystals, probably after the manganese garnet, spessartine, now composed of a mixture of bixbyite with either topaz or quartz or both.

Zinkenite Group.—Spencer[8] describes a twin crystal of chalcostibite (wolfsbergite) from Wolfsberg with 102 as twin plane, not before observed. Also (rare) simple crystals of zinkenite from the same place showing the new form 001. He then shows that by a proper orientation of the crystals of these two minerals the similarity in habit, striation, and twinning may be shown and also their place in the isomorphic zinkenite group as follows:

	$\breve{a} : \bar{b} :$	c
Zinkenite . . $PbS.Sb_2S_3$	0.5575 : 1 :	0.6353
Wolfsburgite $Cu_2S.Sb_2S_5$	0.5312 : 1 :	0.6376
(Chalcostibite, Penfield)	0.5312 : 1 :	0.63955
Sartorite $PbS.As_2S_3$	0.5389 : 1 :	0.6188
Emplectite $Cu_2S.Bi_2S_3$	0.5430 : 1 :	0.6256

He states on the ground of crystallographic measurements that probably the mineral guejarite described by Cumenge as having the composition $Cu_2S.2Sb_2S_3$ will be found to be identical with chalcostibite. This has been proved by Penfield and Frenzel[9] by a re examination of material from Guejar and a study of new material from Huanchaca, Bolivia, supposed to be guejarite. Measurements of crystals from these two localities gave results entirely agreeing with those from typical chalcostibite from Wolfsburg. The chemical constitution of the minerals from the three localities was also shown to be identical, and to satisfy the chalcostibite formula: $Cu_2S.Sb_2S_3$. On the chalcostibite from Huanchaca Penfield observed 20 forms of which 13 were new as follows: 130. 209, 207, 205, 203, 302, 065, 136, 133, 265, 263, 261, 4.12.5. He also shows that the forms observed by Laspeyres, 7.14.8, and 7.21.27, should be 6.12.7, and 134 respectively. In Penfield's paper is further a description by Spencer of a chalcostibite specimen

[8] Min. Mag., Vol XI, No. 52, p. 188.

[9] An. J. Sci., Vol. CLIV, 1897, p. 27.

in the British Museum, likewise from Huanchaca, on which were the further new forms: 233, 354, 474, 475, 476.

The axial ratio adopted is $\breve{a} : \bar{b} : c := 0.5312 : 1 : 0.6395$, and elaborate tables of angles show the thorough agreement of the observations on which is based the identity of guejarite and chalcostibite.

Terrestrial Iron from Missouri.—Allen[10] describes three occurrences of native iron, considered to be of undoubted terrestrial origin, in the Coal Measures of Missouri. In each case the iron was found during the drilling of a well; at Cameron, Clinton Co. the iron formed a mass several inches in thickness in the midst of a solid sandstone, fifty-one feet below the surface; at Weaubleau, Hickory Co. a few pieces of iron were found in a stratum of gray clay, interbedded with sandstone and thin seams of lignite at the depth of thirty-five feet; at Holden, Johnson Co. a mass of iron was struck but not passed through, in a bed of fireclay, underlying an eighteen-inch coal-seam, thirty-seven feet below the surface.

The character of the iron was the same in all the occurrences. It was free from rust, of a lustrous silvery white color, very malleable, hardness 3, specific gravity varying from 7.43 to 7.88. The largest piece obtained weighed 45.4 grams. Some pieces exhibited a layered structure almost amounting to a cleavage. Polished surfaces, etched, showed no Widmanstätten figures. The chemical composition of the iron was nearly the same in the three localities:

	I	II	III
Fe	99.16	99.39	97.10
SiO_2	0.87	0.31	1.65
P	0.207	0.13	0.176
C	0.065	undet'd	undet'd
	99.802	99.83	98.926

The writer appears to consider that these irons represent cases of local reduction, the association with coal or coal-bearing strata being held as significant. It seems worthy of note in this regard that the amount of carbon, both in the irons and in the rocks in which they were situated, was very small.

[10] Am. J. Sci., Vol. CLIV, 1897, p. 99.

PETROGRAPHY.[1]

Petrography of the Marquette Iron Range.—Van Hise and Bayley[2] in their recent description of the Marquette Iron Range in Michigan, give accounts of the petrography of the Archean and of the Algonkian rocks occurring in the region. The pre-Algonkian rocks comprise granite-gneisses, syenites, hornblendic and micaceous schists, and a series of green schists that are cut by peridotites, and by acid and basic dykes. The granites or gneisses are notable for the large quantity of microcline they contain. Although this is present in the most massive phases of the granite, it is much more abundant in those phases that are schistose as the result of pressure. These rocks are much crushed, and have developed in them great quantities of new plagioclase, quartz and muscovite in addition to the microcline above referred to. The syenites are mainly granitic aggregates of orthoclase and hornblende, with some plagioclase and a number of secondary products formed under the influence of pressure. These are the same in character as the secondary products formed in the granite under similar conditions. The green schists are squeezed surface materials. Some of them are squeezed tuffs and others squeezed lavas. The former contain numerous pebble-like masses that are taken to be bombs and rounded lava fragments. The present constituents of the schists are chlorite, sericite, calcite, plagioclase, quartz and sometimes epidote. Much of the plagioclase is in broken crystals lying in a matrix formed of smaller fragments of the same mineral cemented together by a felt of the others in a very finely crystallized groundmass. The structure of many of the schists is typically tuffaceous. These rocks indicate clearly the existence of volcanoes in pre-Algonkian time. The basic schists are associated with acid ones that seem to be squeezed rhyolitic lavas. Analyses of these two classes of schists follow:

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	K_2O	Na_2O	P_2O_5	CO_2	H_2O	Total
Basic schist	61.35	.26	16.45	.94	4.20	3.46	3.12	1.05	5.24	.18	1.98	2.61	= 100.84
Acid schist	70.76	.33	14.83	1.46	3.09	.36	1.99	3.50	.47	.26		2.79	= 99.84

The basic rocks cutting the gneisses and schists are diabases in various stages of alteration, and the acid ones are quartz porphyries. These have been carefully described by Williams.[3] The peridotite of

[1] Edited by Dr. W. S. Bayley, Colby University, Waterville, Maine.

[2] Monograph XXVIII U. S. Geol. Survey, Washington, 1897.

the Marquette district was carefully described years ago by Wadsworth. The only additional fact of importance added by the authors with respect to this rock concerns its composition. An analysis of a very fresh specimen gave:

SiO_2	TiO_2	Al_2O_3	Cr_2O_3	Fe_2O_3	FeO	MnO	NiO	CaO	SrO	BaO	MgO	K_2O	Na_2O	CO_2	P_2O_5	H_2O	Total
39.37	.66	4.47	.68	4.96	9.13	.12	.21	3.70	tr	tr	26.53	.26	.50	1.23	.17	7.95	= 99.94

A few hornblende-schists met with in certain portions of the area studied are shown to be altered igneous rocks, possibly recrystallized lavas.

The micaceous schists are well banded rocks with a distinct dip and strike. They are often interlaminated with thin bands of hornblende-schists with which they are perfectly conformable. These micaceous schists embrace muscovite-schists, biotite-schists and feldspathic biotite-schists, most of which are so much decomposed that their original composition is difficult to determine. It is probable that they are crystallized acid lavas or tuffs.

In the Algonkian series are quartzites, conglomerates, graywackes, slates, dolomites, grünerite-magnetite schists, jaspilites, mica-schists and a series of basic tuffs that have suffered metamorphism until they are now largely hornblende-biotite-schists. The production of hornblende in these tuffs is on a very extensive scale. The amphibole is in large plates that are more or less idiomorphic, and nearly all of these are cellular in structure. The greenstones that are intrusive in the iron formation are altered diabases, in only a few of which augite can still be detected. These rocks have heretofore been generally known as diorites. In the western part of the district where the squeezing has been more intense than elsewhere much quartz and biotite has been developed in them, and the rocks present a very different aspect from the more normal phases.

All the rocks mentioned above are described in detail, and many colored reproductions of polished hand specimens of limestones, slate and jaspilite illustrate the report.

The Rock-formation of the Silver Cliff and Rosita Hills District, Colorado.—The mines of the Silver Creek and Rosita district are mainly in volcanic rocks. The eastern portion of the area is the seat of an old volcano which erupted andesite, rhyolites and trachytes both in lava and in tuff form. These constitute the Rosita Hills. North and east of these are the old granites and gneisses. In the

[3] Bull. 62 U. S. Geol. Survey.

neighborhood of Silver Cliff only the rhyolites are present. The granites intrude the gneisses, both being early Cambrian or pre-Cambrian. The volcanic series dates from the early Eocene; in this and in some other respects being like similar rocks at Cripple Creek and at other volcanic centres in the State. Both the Rosita and the Cripple Creek volcanoes are regarded as small outlying vents connected in origin with the much larger eruptions of the San Juan and South Park regions.

The gneisses of the Silver Cliff-Rosita Hills district are described by Cross[4] as variable in composition, no one type persisting over any great area. They consist of microcline, orthoclase, quartz and biotite, muscovite, hornblende or augite, and by variation in the amounts of either one or several of these constituents they grade into quite different types. The quartz and the bisilicates are often segregated in thin layers or streaks, thus giving the gneiss a banded aspect. Among the principal types represented in the complex, the augite-hornblende-gneiss is the most definite. It is a basic gneiss composed of a basic plagioclase and numerous intergrowths of augite and hornblende. The old gneisses and granites are cut by dykes of syenite, diabase and peridotite.[5]

The earliest member of the volcanic series is a hornblende-mica-andesite which occurs principally as a tuff. This was followed by massive effusions of an augite-biotite-andesite containing large phenocrysts of orthoclase and small crystals of plagioclase surrounded by orthoclase rims. The andesites are cut by dykes of an augite-diorite containing biotite and altered olivine, and in some facies of the rock considerable orthoclase.

A later lava than the andesite was the dacite, which differs from the augite-andesite in the presence of quartz and in the subordination of the dark silicate to the feldspars. Orthoclase is absent from the dacites, and the plagioclases present are nearly all andesine.

The next in age and the most abundant of the lavas are rhyolites. These vary greatly in character, but nearly all phases are devoid of dark silicates. They occur in massive and in banded ledges, and in others remarkable for the great abundance in them of very large spherulites. These have been carefully studied by the author and reported upon in another place. In addition to the lavas tuffs, agglomerates and other evidences of explosive volcanic activity are noted in the vicinity of Rosita. Following the rhyolite came another biotite-augite-andesite, and finally a trachyte of normal character.

[4] 17th Ann. Rep. U. S. Geol. Survey, p. 269.

[5] Cf. Proc. Colorado Sci. Soc., Vol. II, 1887, p. 223.

One of the most interesting rocks of the district is the Bassick Mine agglomerate made up of fragments of many different rocks cemented by fine debris of the same character. This is now usually so much decomposed that its original constituents can in many cases no longer be recognized.

In addition to the volcanic rocks mentioned above, a mica-dacite and a limburgite were observed. They are, however, quite rare. All the volcanic rocks have been decomposed by solfataric action, yielding products of various kinds, the two most important of which are a white siliceous clay resulting from the alteration of pitchstone and a quartz alunite rock produced from rhyolite. Analyses of the pitchstone and its alteration product follow:

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO	K_2O	Na_2O	H_2O	Total
Pitchstone	71.56	13.10	.66	.28	.16	.74	.14	4.06	3.77	5.52 =	99.99
Clay	71.71	12.36	1.10		.17	1.11	1.21	.36	.17	11.97 =	100.16

The andesite is often muscovitized, all of its constituents but augite and orthoclase passing over into aggregates of muscovite apparently with great ease.

The report closes with a discussion of differentiation in which the author does not reach any definite conclusions, except that in the case of the Rosita rocks much of the differentiation which resulted in the different phases of the various types must have taken place either after the lavas had reached their present position, or at any rate at no great depth under the surface.

Notes.—Wolff[1] gives a description and a map of the exposures of eruptive rocks occurring in Sussex Co., N. Y. These exposures include those of the well known eleolite-syenite and associated dyke rocks at Beemerville.

PALÆONTOLOGY.

Schuchert's Synopsis of American Fossil Brachiopoda.[2]—Students of Brachiopoda, as well as Mr. Schuchert, are to be congratulated upon the publication of this important work. Its preparation has extended over a period of eleven years, and entailed references

[1] Ann. Rep. State Geol. of New Jersey for 1896, p. 91.

[2] A Synopsis of American Fossil Brachiopoda, including Bibliography and Synonymy. By Charles Schuchert, Bulletin U. S. Geol. Survey, No. 87. 8°, 464 pp., Washington, 1897.

and cross references to upwards of 2,500 species, necessitating about 10,000 citations. All the literature relating to North and South American fossil Brachiopods is recorded in this synopsis, and 2,053 valid species are recognized, of which 1,922 are North American, and 1,859 are restricted to the Paleozoic. It is estimated that 6,000 Paleozoic species have been described for the whole world; therefore about one-third of the number occur in North America.

In the American Mesozoic, a marked scarcity of Brachiopods exists, since but 49 species have been recorded, and many of these are rare. The Cenozoic representation is even smaller, there being but 14 species. In the North American Cambrian, there are 116 known species, with 319 in the Ordovician, 311 in the Silurian, 662 in the Devonian, while the Carboniferous representation declines to 478. In America, the class practically became extinct with the close of the Paleozoic, for but 11 species are known from the Triassic and 13 from the Jurassic. During the Ordovician, the increase was extremely rapid and all the essential types occur near the base of the system in the Calciferous. The culmination of the class was attained during the Devonian.

Under the geographic distribution of Brachiopods, it is stated that 537 species had great areal or horizontal dispersion, and 121 species are common to North America and other continents. The specific distribution increases with ordinal rank, so that while 25 per cent of the Atremata had dispersion, the Neotremata show 27 per cent; and the higher orders, the Protremata and Telotremata, each show 32 per cent. The order Atremata is best developed in species and genera in the Cambrian and Ordovician systems; the Neotremata in the Ordovician; the Protremata in the Ordovician, Silurian, and Devonian; and the Telotremata in the Devonian. The climax of differentiation is, therefore, chronologically related to phylogenetic or sequential origin. But 8 genera are known to pass from the Paleozoic to the Mesozoic. There are in all 327 Brachiopod genera, 227 of which are Paleozoic.

After the discussion and tables illustrating the geologic development and geographic distribution of the American fossil forms, the author presents a chapter on Brachiopod terminology, in which all the current descriptive terms are defined. The biologic development is then taken up in detail for the separate orders and for special important features, as the protegulum, prodeltidium, cardinal areas, articulation, deltidium, spondylium, etc. The morphology of the brachia is discussed in a separate chapter prepared for this work by C. E. Beecher.

The various schemes of classification applied to the Brachiopods are taken up chronologically, and the strong and weak points of each are

critically reviewed. The author then enunciates the principles of a classification based on the history of the class and the ontogeny of the individual. The ordinal grouping proposed by Beecher in 1891 is the only one for the Brachiopods which is founded upon these principles, and is therefore adopted. Schuchert has greatly elaborated and developed the classification along these lines until it is now very complete and satisfactory.

The orders are based mainly upon the nature of the pedicle opening; superfamilies upon the persistent internal characters of the shell; and families within the superfamilies upon a combination of common external and internal generic characters. The generic limitations and the disposal of species are largely in accordance with the work of Hall and Clarke.

The final chapter containing the index and bibliography necessarily constitutes the bulk of the work. The arrangement is alphabetical and will greatly facilitate references to any species or genus. The plan of treatment is as follows: The generic name and author are first given, and also the genotype, or type species of the genus, together with references to all the literature. Then follow the species under the genus, each with its geological distribution, references and synonymy, geographical position, and in many cases, observations on the synonymy, structure, and affinities.—C. E. B.

BOTANY.

Bailey's Principles of Fruit Growing.[1]—This volume of the Rural Science Series, which is issuing under the editorial management of Professor Bailey, contains only eight chapters, but goes into an unusual amount of detail in the discussion of all phases of fruit-growing, from the primary location of the fruit farm to the handling and marketing of its produce. Few problems are as complicated as those underlying the art of horticulture, and the author has done well in analyzing them quite fully, for there is little doubt that intelligent observation in any locality can supply better data for local practice than can be laid down empirically in the best book. Though a rather curiously classified inventory of fruits occupies the early pages, the discussion of practical details is chiefly limited to the varieties growing in the temperate part of the United States.—T.

[1] The principles of fruit-growing. By L. H. Bailey, New York. The Macmillan Company, 1897, pp. xi+508. $1.25.

EMBRYOLOGY.[1]

Fertilization.—Our present conceptions of the meaning and of the cell factors concerned in the act of fertilization have been based so largely upon the views of Boveri and these arose so directly from the study of the eggs of *Ascaris megalocephala* that it is of the greatest importance to know how far we rest assured in the knowledge of the truth in this classical object.

The well-known editor of LA CELLULE has with M. H. Labrun restudied fertilization in this worm and obtained facts quite at variance with those commonly accepted. Professor Carnoy studies sections that are obtained after killing the eggs with a mixture of absolute alcohol, chloroform and acetic acid saturated with corrosive sublimate and this certainly yields most beautiful pictures of reticular appearances throughout cell and nucleus.

While Boveri regarded the introduction of a centrosome by the sperm as a most important part of fertilization Carnoy denies that there is any such fact. For Boveri, the sexes are not alike since the egg has no centrosome to start the process of fertilization and the sperm has such a centre. For Carnoy, there is entire equality of the sexes since both sperm and egg each furnish a centrosome for the first cleavage and in every other way the fertilized egg is a combination of the same elements from both sexes.

A cardinal point in Carnoy's observations is the fact, as claimed, that the nucleoli pass out from the nuclei and become the centrosomes! The centrosomes also vanish after each cleavage and *do not divide* to make new ones!

A summarization of his facts includes the following assertions: 1. At the last division of the series of cells that form eggs, the centrosome vanishes from the protoplasm and new ones are formed in the nucleus of the unripe egg. 2. In the formation of the polar bodies these centrosomes emerge from the nucleus and function; perhaps they disappear after the first, and are formed again for the second, polar body. 3. Both polar bodies are formed with the presence of centrosome and asters; but these structures then disappear and there is no centre left in the protoplasm of the ripe egg. 4. The sperm introduces a large mass of reticulum and this acts upon the reticulum of the egg to pro-

[1] Edited by E. A. Andrews, Baltimore, Md., to whom abstracts, reviews and preliminary notes may be sent.

duce a radiating change that gradually works over and modifies the entire egg. Boveri's *archoplasm* does not exist except as this radiating area of influence. 5. In this radiating mass there is no centrosome, no sperm centre—nothing but a mass of nucleo-albuminiferous enchylema discharged from the sperm and in process of solution. 6. Up to the time of cleavage there are no centrosomes in the protoplasm and there can be no "quadrille of the centres." 7. The centrosomes arise early in the pronuclei, one in each, as nucleoli. 8. One centrosome comes out of the sperm nucleus and one out of the egg and they function as soon as they get into the eggs protoplasm, to form asters. 9. The spindle is made from the network of the nucleus, (fused sperm and egg nuclei), under the influence of the centrosomes. 10. The centrosomes do not divide but dissolve; the asters also disappear without dividing. 11. In each new nucleus two new nucleoli arise and after a dormant period pass out to function as centrosomes in the next cleavage.

Fertilization is thus a most complex process in which two individuals of different origin merge into one new entity of mixed nature; mixed not only in chromosomes but in all parts; cytoplasm, caryoplasm, centrosomes, all of double origin, male and female.

The egg may transmit the properties of both parents since it acts as a mixed being of double origin in all parts, throughout cleavage and subsequently. The entire egg not only the nucleus but also the outer protoplasm may be concerned in heredity.

As life remains a complex of mysterious and unexplained phenomena the author deems it folly to venture hypotheses as to the nature of heredity. "Sachons avouer notre ignorance profonde et nous arrêter à la limite de notre modeste savoir."

PSYCHOLOGY.[1]

The Physical Basis of Pain.—The unsettled state of opinion among psychologists in regard to the nature of pain was touched upon last year in these notes.[2] The chief points at issue are whether pain and pleasure should be classed as sensations or as affective elements of consciousness, and how far a distinction should be drawn between so-called physical pain (Schmerz) and pain in the sense of displeasure (Unlust). The older theories in general regarded pain solely as a feel-

[1] Edited by Howard C. Warren, Princeton University, Princton, N. J.

[2] November, 1896, p. 948.

ing, without any distinct physiological basis at all. The use of a single term in English for both Schmerz and Unlust has tended to obscure their difference, but recent discussion has brought it out with greater distinctness, and many writers now regard pain—at least when it involves some definite locality, as in the case of head-ache, tooth-ache, pricking, etc.—as a real sensation.

Attempts have been made, in connection with this view, to discover definite end-organs and nerve tracts for the pain sense. The probability of the existence of such a physical basis has lately been urged with great force by a number of writers, on the evidence furnished by certain pathological cases, where localized hyperalgesia or analgesia occur without any marked alteration in the senses of pressure or temperature. They argue that if pain can be heightened or deadened without disturbance of the other dermal senses, it must be furnished with a distinct sensory apparatus of its own. Numerous clinical cases, reported by Dr. Henry Head in a series of articles in "Brain,"[3] lend considerable support to this view. These observations and others have been regarded as direct evidence that pain has a distinctive anatomical and physiological basis—either a complete set of end-organs and nerve apparatus, or at least a separate conducting tract and cortical center. Several objections have been raised against the more radical view, the chief being that no type of end-organ has been found in the skin, apart from those required for the senses of pressure and temperature.

A recent paper by Prof. Witmer, of Pennsylvania, reported at the British Association this summer and since published,[4] recognizes the force of this criticism, and favors the modified view of a spinal tract and center for pain. Prof. Witmer reviews the clinical and experimental evidence in great detail, taking up the parts of the sensory apparatus separately.

"There is no conclusive anatomical evidence," he says, "for the existence of a peripheral sense organ or nervous end organ for pain. There is no conclusive evidence for the existence of peripheral pain nerves or peripheral sensory neurons. Much evidence justifies the conclusion that all or some peripheral nerves may, under adequate stimulation, act with specific pain-producing function; that such nerves may lose this function without a loss of other functions or may lose their other specialized sensory functions without losing the pain function. Local peripheral analgesia and analgesia due to compression or

[3] Vols. XVI, p. 1; XVII, p. 339, and XIX, p. 153.

[4] Twentieth Century Practice of Medicine, 1897, XI, p. 905.

disease of the peripheral sensory neuron make the assumption of peripheral pain nerves and sense organs one that stands closely related to the facts.

"There is a specialized pain tract in the spinal cord which is certainly constituted in part by the gray column, and which may be composed of a part of the gray column on both sides, including the commissure and a part of the lateral tract. Into this pain tract, nerves from the sympathetic system and from the internal organs, together with all specialized nerves from the periphery, discharge their stimulation when this is relatively intense. The intensity necessary to bring about this discharge may be that which is sufficient to overcome the resistance offered by the tract. This tract passes up through the optic thalamus and posterior limb of the internal capsule, the 'carrefour sensitif,' into the cerebrum, and reaches some region unknown, but probably a part of the somæsthetic area. This hypothetical region of the somæsthetic area may be looked upon as the pain centre.

"There is some warrant of justification for considering the pain tract in the spinal cord as the spinal nerve organ of pain, which, together with the hypothetical specialized cortical centre, constitutes the specific organ of pain. Any part of this central pain organ may be stimulated in the cortex or below it, either by stimuli discharging into it through normal physiological processes, by spinal or cortical association, by irritation due to disease, and perhaps by a vascular disturbance within the central nervous system.

"Thus pain may be a sensation of purely central nervous origin. The arousal of pain by stimuli and its presentation in consciousness along with other sensations may be explained by the simultaneous association of pain with other forms of stimulation—an association that may take place at any level of the nervous system. When such association takes place in the cortex, we have conscious association, the connection of pain with other sensations, with percepts, or with ideas." * * * * The universality of pain association with sensations of maximal intensity is explainable anatomically and physiologically by the discharge of intense stimuli carried by all peripheral nerves into the central pain organ: that this central pain organ has no peripheral nerves of its own, possessing a specific pain function and no other, can receive satisfactory explanation only from biological considerations of the significance of pain as a warning against dangerous stimuli of the environment. This fact would suggest an early phylogenetic development of a pain sense in the organism; in fact, the pain sense may have been the first of all the special senses."[5]

[5] Op. cit., pp. 940-941.

If this analysis be accepted, it will naturally follow that pain must be regarded as a sensation alongside of the sensations of pressure, temperature, etc., but differing from them in having no specific end-organ, and depending upon them for its stimulation. It is scarcely necessary, then, to turn to introspection for further evidence. Prof. Witmer says: "Pain is a simple, unanalyzable mental content. It should therefore be called a sensation." The advocates of a dual or triple divison of the elementary data of consciousness will, of course, deny this argument *ab initio*. But the physiological evidence is another matter, and the hypothesis is sufficiently well grounded to call for careful consideration and discussion.—H. C. W.

Baldwin's Social and Ethical Interpretations in Mental Development.[6]—Following up the line of thought of his earlier work, on "Mental Development in the Child and the Race," Prof. Baldwin, in the present volume, considers the social aspects of that development. The connection between the individual and society he believes to be very close. On the one hand the mental growth of the individual is more or less controlled by conditions in the social environment; on the other hand, the forms of organization, growth and activity of society are analogous to those of the individual organism. Prof. Baldwin examines both of these relations in turn. The development of the notion of Self in the child proceeds *pari passu* with the rise of the notion of Other. The social environment furnishes him with a vast store of traditions and customs (social heredity) which form an important factor in his mental life; this same environment supports him where he conforms to its standards, and "suppresses" him where he does not. The inventive function, too—that by which the individual arrives at new results, different from his mere imitations of others—is guided by social approval and disapproval. In all these phases of individual growth the social environment supplements the instincts and other endowments derived from biological and psychological heredity. The author concludes this part of his work with an analysis of the elements in man's mental constitution which fit him for the social relation (sympathy, social intelligence, ethical sentiment, etc.), and a comparison of the sanctions, personal and social, which determine his acts.

In taking up the problem from the standpoint of the social organization, the author considers (1) the forces which control society, (2) the

[6] Social and Ethical Interpretations in Mental Development. By James Mark Baldwin. New York: The Macmillan Co., 1897, pp. xiv, 574, $2.60.

material and process of social organization, and (3) the nature of social progress. As regards the first question, he finds two distinct influences at work in society; the individual is a *particularizing* force, while the social organization itself tends in the direction of *generalization*. The *matter* of society consists, he says, of "intellectual states, such as imaginations, knowledges and informations." These "originate in the mind of the individuals of the group, as inventions, more or less novel conceptions, what we have called 'particularizations.' At their origin there is no reason for calling them social matter, since they are

SELECTION.[1]

SORT.	MEANS.	RESULT.
1, 2. Natural Selection { I. (Darwin, Wallace, Spencer) [40]. II. (Eimer) [40].	1. Struggle for Existence (Darwin, Wallace).	1. "Survival of the Fittest" Individuals (Spencer).
	2. Inherent Weakness, without Struggle.	2. Destruction of Unfit Individuals.
3. Germinal Selection (Weismann).	3 Struggle of Germinal Elements.	3. Survival of Fittest Germinal Elements.
4. Intra-Selection (Roux, Weismann, Delage).	4. Struggle of Parts (Roux).	4. Survival of Fittest Organs.
5. Functional Selection (Baldwin).	5. Overproduction of Movements, (Bain, Spencer, Baldwin).	5. Survival of Fittest Functions.
6. Organic Selection (Baldwin, Osborn, Lloyd Morgan) [Appendix A].	6. Accommodation (Baldwin); Individual Adaptation (Osborn); Modification (Lloyd Morgan).	6. Survival of Accommodating Individuals.
7. Artificial Selection (Darwin).	7. Choice for Planting and for Mating Together.	7. Reproductions of Desirable Individuals.
8. Personal Selection[2] [40].	8. Choice.	8. Employment and Survival of Socially Available Individuals.
9. Sexual Selection (Darwin) [40].	9. Conscious Selection by Courting, etc.	9. Reproduction of Attractive Individuals.
10. Social Selection[2] [40, 120].	10. Social Competition of Individuals and Groups with Natural Selection (Malthus, Darwin).	10. Survival of Socially Fittest Individuals and Groups.
11. Social Suppression[2] [38 ff.].	11. Suppression of Socially Unfittest (by Law, Custom, etc.)	11. Survival of Socially Fit.
12. { Imitative Selection[2] [40, 121, 307]. Social Generalization[2] [121, 310 ff.].	12. Imitative Propagation from Mind to Mind with Social Heredity.	12. Survival of Ideas.

[1] I am indebted to Professor Lloyd Morgan for several suggestions utilized in the Table.

[2] Suggested in this work.

particular to the individual. They become social only when society—that is, the other members of the social group, or some of them—also thinks them, knows them, is informed of them. This reduces them, from the individual and particular form to a general or social form, and it is only in this form that they furnish social material, through what has been called, again, the 'generalization' effected by society" (pp. 487–8). The *process* of organization is through imitation: the individual particularizes in his exercise of imitation; society, by imitating the thoughts of particular individuals, generalizes them.

The *progress* of society is, in its method, direction and impelling motives, "analogous to the growth of consciousness rather than to that of the biological organism;" hence Prof. Baldwin objects to the application of the term *organism* to society, and prefers *organization.*

It would be impossible here to enter into any more minute examination or criticism of the positions maintained in this work. Attention should be called, however, to Prof. Baldwin's classification of the various sorts of developmental "Selection." The accompanying table, reproduced from Appendix B of the book, shows a number of distinct types, together with the authors who have discovered or elaborated them. The arrangement begins with the purely biological agencies, and proceeds up through the psychological to the social. The table furnishes a valuable contribution to evolution literature; the distinction drawn between the means, the result, and the name given to the process itself, clears up a number of points in regard to which considerable confusion has hitherto existed.—H. C. W.

ANTHROPOLOGY.

The History of Mankind.[1]—The second volume of the translation of Prof. Ratzel's "History" more than meets the expectations of students of ethnography and others who have awaited its appearance with no little interest. The "modern method" of treatment and the wealth of illustrations continue to be prominent and pleasing features.

"Book II" describes (1) The Cultured Races of America; (2) The Ancient Civilized Races of America; (3) The Arctic Races of the Old World. Book III, The Light Stocks of South and Central Africa. Book IV, The South and East Africans.

The American tribes are not considered in detail, but in culture groups as the Forest and Prairie Indians of North America, the Forest Indians of Central and South America, the Pategonians, the Fuegians, etc. No general treatise has heretofore so fully described the inhabitants of the southern portion of the South American Continent. Some of the prevailing stories regarding their utter wretchedness are contradicted, and we learn that "the Fuegians are, at the bottom, Indians like all the rest," and our estimate of their disposition and

[1] *The History of Mankind.* By Professor Friedrich Ratzel. Translated from the second German edition by A. J. Butler, M. A., with introduction by E. B. Tylor, D. C. L., F. R. S., with colored plates, maps and illustrations. 1897, N. Y., Macmillan, Vol. II, pp. 562.

intellect increases with nearer acquaintance. Throughout the volume, attention, justly due but seldom paid, is given to that important factor of culture growth, geographical environment. The author describes the advantages offered by the flora and climate of temperate and tropical America, and briefly comments upon the disadvantage to the nascent civilizations of the absence of the larger domestic animals. Very little space is given to speculations regarding the origin of the American race. We are told that "there can be no doubt America possessed human inhabitants as early as the Age of the Drift, though the conflict as to Tertiary man is as far from being settled there as it is in Europe." The date of the workshop for the manufacture of chert-flakes, which was discovered in Minnesota, is accepted without question as "interglacial." The Trenton Ghost is not raised. The belief in the unity of the American race is based upon the ground of long isolation and consequent assimilation rather than upon community of descent. Virchow's statement is quoted with approval "that from the point of view of anthropological [somatological] classification there is no real unity among the aboriginal population of America," a typical American skull does not exist, "in every large burying-ground all lengths and shapes are represented."

The Eskimos are connected with the Indians, "as it seems too hazardous to rank them with the true Monogoloids. But northeast Asia is unquestionably a region of transition which finds its continuation in northern America." We may hope that the results obtained by the Jesup expedition will have an important bearing upon this question. Notwithstanding the excellent authorities quoted we can scarcely admit that the stature of the Eskimo is "low," but are more inclined, after a journey through the entire region occupied by the "Western Eskimo" west of the Mackenzie, to agree with a recent paper by Mr. Murdoch, in which he states that they are of "medium height, while much taller men are far from uncommon." The Eskimo has been cleared of the charge of stuffing himself with raw meat and drinking quantities of train oil, but not so the reindeer—Chukchi, by whom "frozen fish is eaten raw; the head of a freshly-killed reindeer has also to be devored raw, and his liver, ears, and kidney-fat are regarded as tid-bits only when raw. Melted fat or butter is a favorite drink, and is consumed in quantities of several pounds." Among the Hyperboreans as among so many races in more favored climes, the withering influences of civilization are at work. "The pastoral and hunting races of northern Asia have begun to die out extensively" (p. 217).

We are given the benefit in Books II and III of compilations from the recent extensive additions to our knowledge of Africa and its

inhabitants. Type specimens from the immense African collections which have been acquired recently by European museums are represented by numerous drawings and many new and excellent photographs of natives are reproduced. We are led to believe (p. 250) that Africa was peopled from the "eastward," probably by way of Arabia. The similarity of certain art products, social customs and anatomical characters between the African and Oceanic races would seem, to many anthropologists, to be of greater value as evidence of unity of origin than the resemblances between the myths of the two regions upon which Professor Ratzel lays some stress. Whatever his origin may have been, the future of the African is considered to be of greater importance; what that future will be we may form some estimate from the excellent account given of his present condition.

It is to be regretted that a map of America, at least of the South American tribes, is not given. Ornithologists will certainly not admit the capercailzie among American *Tetraonidæ* (p. 9), and if the "partridge" is "a species of quail," as in the south where *Colinus virginianus* is so called, then it cannot be of "about the same size" as the prairie hen, which, however, does equal the size of *Bonasa umbrellus*, the "partridge" of the north. The pigeon *was*, not is, abundant. *Ursus ferox* is given for *U. horribilis*. A cheerful and lively disposition might have been ascribed to many other Indian tribes besides those of the "sunny regions in the southern Rocky Mountains," for example, the northern Athabascans who possess a cheerful temperament in spite of the depressing influences of their inhospitable environment. The Athabascan tribe referred to as "Ojibbeways" on p. 28, is probably the Chippewyan group which occupies the region between the Great Slave Lake and Lake Athabasca, a thousand miles northwest of the territory of the Ojibzways of Algonquin stock.

The work, as a whole, is clear and comprehensive, a contribution which we believe will do much toward explaining the nature and purpose of this department of anthropology to the lay reader, and which supplies the student with a text-book of the greatest value.—F. R.

SCIENTIFIC NEWS.

The French School of Anthropology entered upon the work of its twenty-second year on November 3d. The program for 1897–98 is as follows:

(1). G. de Mortillet—Prehistoric Anthropology; Paleontology by regions; Prehistoric and Protohistoric of divers countries.

(2). Capitan—Pathological Anthropology; maladies arising through auto-intoxication or auto-infection. Their role in anthropology.

(3). André Lefèvre—Ethnography and Linguistics; The Origin and Development of the French Language.

(4). Georges Hervé—Ethnology; Ethnology of Europe. First, The Ibero-Aquitains and the Basque Question; second, The European Blonde Populations.

(5). J. V. Laborde—Biological Anthropology; The Transformation and the Equivalence of the forces of Biological Anthropology; The Nerve Cell or Neuron according to the Modern Conception; The Special Senses of Hearing and of Sight (organic and functional evolution).

(6). P. G. Mahoudeau—Zoological Anthropology; The Zoological Origin of Man.

(7). Franz Schrader—Geographical Anthropology; Earth and Man; Oceanica and Africa.

(8). L. Manouvrier—Physiological Anthropology; The Anatomical-physiological Components of Character.

(9).—Ch. Letourneau—Sociology (History of Civilization); Mental Evolution in the various Races and Societies.

(10). A. de Mortillet—Comparative Ethnography; Ceramics among Primitive Peoples, Ancient and Modern.

The courses are open to the public and are gratuitous.

Recent deaths: Ferdinand Béclard, paleontologist in the Brussels Museum.—Prof. Michael Angelo Consoli, botanist, at Palermo, May 13th, aged 85.—Dr. Heydenreich, lepidopterist, at Osnabruck, May 18th.—Dr. J. Braxton Hicks, well known for his papers on zoology and botany, at the age of 74.—Dr. Holmgren, professor of physiology in the University of Upsala, and well known for his researches on color blindness, aged 66.—Rev. Robert Hunter, botanist, at Epping Forest, England, February 25th, aged 74.—Jules Jullien, of Havre, student of Polyzoa.—Dr. Anders Johann Malmgren, the well known student of northern annelids and fishes, at Uleaborg, Finland.—Dr. Felix Georg Hermann August Mojsisovics, Count of Mojsvar, professor of zoology in the Technical School and custodian of the zoological collections in Graz, August 27th.—Alfred Moquart, professor of anatomy at Brussels, June 5th, aged 42.—Dr. Jules Bernard Luys, neurologist, at the age of 69.—Dr. G. Ossonski, geologist, at Tomsk, Siberia, April 6th.—Franz Pulozky, author of the Copper Age in Hungary and former director of the National Hungarian Museum at Budapest, aged 82.—

Samuel James Augustus Salter, botanist, at Basingstoke, England, February 28th, aged 72.—Prof. Paul Schutzenberger, physiological chemist of Paris, aged 67.—P. B. L. Verlot, botanist, at Verrières-les-Brusson, France.—R. Allan Wright, economic entomologist, near Aukland, N. Z., December 22, 1896, aged 73.

Among the recent appointments we notice the following: Dr. Charles R. Bardeen, assistant in anatomy at Johns Hopkins University; Prof. Belajeff, director of the botanical gardens at Warsaw; Dr. Pio Bolson, assistant in the botanical institute at Padua; Dr. Edward Fischer succeeds his father (Prof. L. Fischer) as professor of botany in the University of Bern; Dr. Elisha Gregory, Jr., has been appointed instructor in histology and embryology in Harvard Medical School; Dr. Herbert L. Jones, associate professor of botany in Oberlin College; Dr. Julius Paoletti, of Padua, professor of natural history in the Melfi Technical Institute; Dr. M. Raceborski, of Cracow, goes to Java as professor of botany in the experiment station for sugar production at Kagok Tegal; Dr. Hans Reusch, director of the Geological Survey of Norway, Sturgiss-Hooper professor of geology in Harvard University; Dr. Rodet, professor of bacteriology in the University of Lyons; Dr. W. Ernest Thomson goes to Anderson College, Glasgow, as successor to Dr. Campbell Black in the chair of physiology; W. W. Watts, assistant professor of geology in Mason College, Birmingham, England; Henry C. Williamson, naturalist to the Fishery Board for Scotland; Dr. Zehntner, professor of entomology at the station at Kagok Tegal, Java; Dr. Zelinka, of Graz, professor of zoology in the University of Czernowitz, Austria.

Mr. Gary N. Calkins presents in *Science* an account of the Columbia Expedition to the Pacific Coast. The party consisted of seven. The work began at Port Townsend on Puget Sound, but when the party arrived there it was too early to obtain much in the way of embryological material, so all proceeded to Alaska where, although the facilities for collecting were poor, large collections were made both for anatomical and for embryological studies. In its return to Puget Sound the expedition had difficulty in getting return passage on account of the numbers of excursionists crowding the regular boats. They took passage finally in a returning boat the "Mexico," which had brought up a Klondyke party. On the return voyage the Mexico ran into a rock in a fog and sank in about two hours in about 500 feet of water, carrying down with her all the collections, instruments, notes, etc., of the expedition. There was no loss of life and all were landed soon after at Port Townsend.

Among the work accomplished by the Johns Hopkins party at Port Antonio, Jamaica, the past summer was the following: The late Professor Humphrey collected material giving the complete embryology of one of the palms, of Casuarina and of the wild ginger, as well as much material upon the shell-boring algæ. The late Dr. Conant continued his studies of the rare group of Cubomedusæ. Dr. Clarke paid especial attention to the embryology of the echinoderms. Mr. Sudler obtained abundant material of the metamorphoses of the crustacean Lucifer. Mr. Grave studied the development of the brittle stars, while Mr. Berger collected a large amount of material for the study of the false scorpions. Mr. Duerden, of the Institute of Jamaica, was a guest of the laboratory and studied the sea anemones. Until the fatal last week the work of the laboratory was most successful. All of the specimens and drawings of the party have been preserved, and the results will be worked up later.

A correspondent has been kind enough to call our attention to an error on page 829 of the September number, where we say that natural history specimens are now charged postage at the rate of one cent for every two ounces. As a matter of fact, we are informed, this ruling of the recent postal congress does not take effect until January 1, 1899.

The late Theodore Lyman, whose death was recently noticed in these pages, gave his library of works upon Natural History, to the Museum of Comparative Zoology of Harvard University.

The Indian section for the collection of funds for the Pasteur memorial has sent to Paris £442 17s. 6d.